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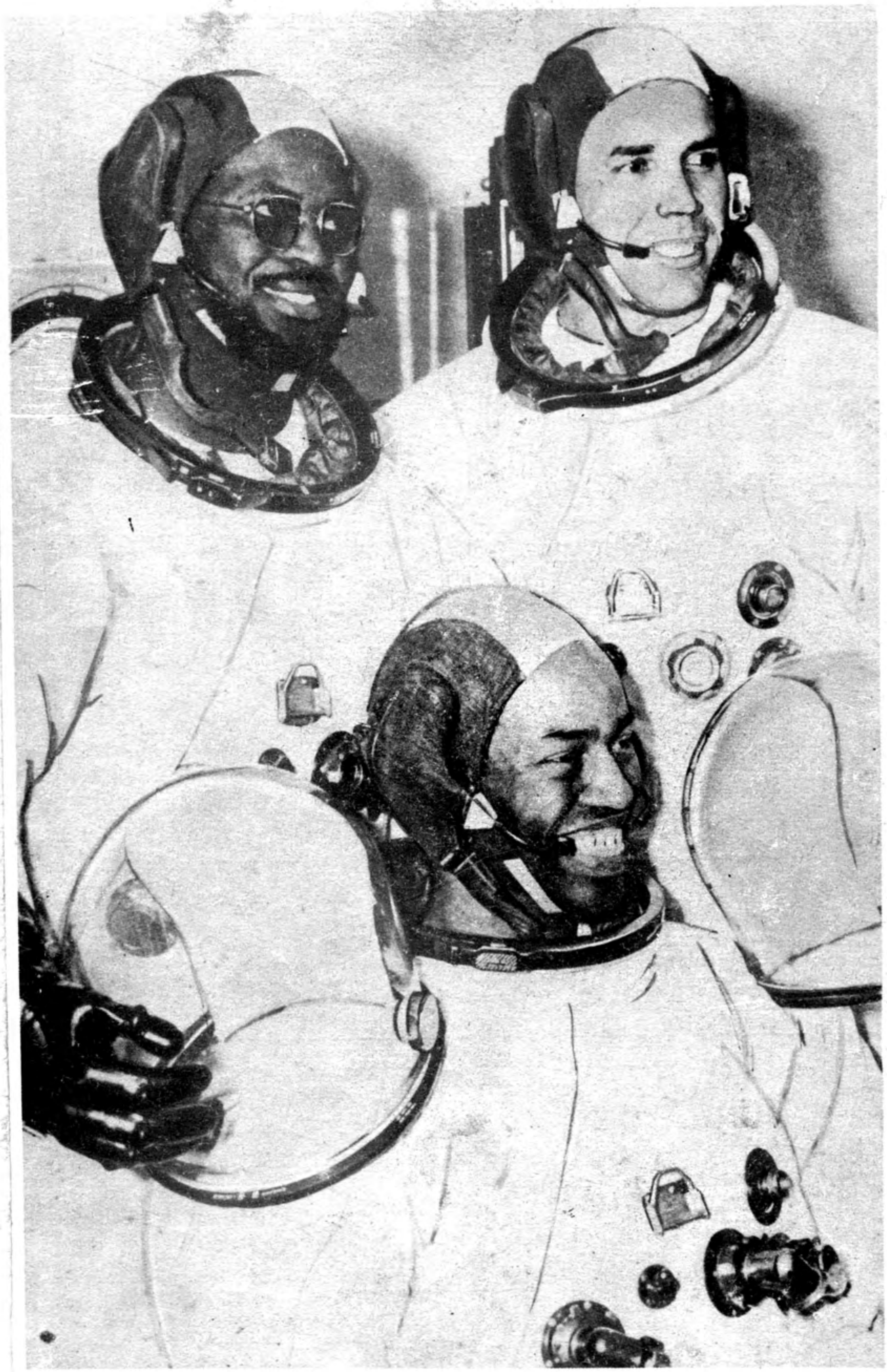

Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

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COVER

SHUTTLE ASTRONAUTS. Thirty-five men and women forming the eighth group of astronauts were selected early last year to train as Pilots and Mission Specialists in the era of the Space Shuttle. Three of their number are seen in this picture wearing extravehicular mobility suits at the Johnson Space Center, Houston, Texas. They are Guion S. (Guy) Bluford (seated); Ronald E. McNair, left, and Frederick D. Gregory is a Pilot-Astronaut and the others are Mission Specialist-Astronauts.

National Aeronautics and Space Administration

SPACEFLIGHT

A Publication of The British Interplanetary Society

VOLUME 21 NO 1 JANUARY 1979 *Published 22 December 1978*

MILESTONES

October

10 Seasat, NASA's experimental ocean monitoring satellite launched 26 June, stops transmitting data shortly after midnight EDT whilst over Australia.

11 *Tass* announces that the Soviet Union is to carry out launchings of carrier rockets into an area of the Pacific Ocean having a circumference of 130 nautical miles centred 34°01′ north and 176°53′ west. Ships and aircraft are requested to stay away from the area each day between 06.00 hrs and 19.00 hrs local time.

13 NASA launches Tiros N meteorological satellite by Atlas rocket from Western Test Range, Lompoc, California (see page 14).

13 Cosmonauts on board Salyut 6 complete refuelling of station from Progress 4.

16 New Soviet space tracking ship, *Kosmonaut Georgi Dobrovsky*, starts maiden voyage from Leningrad.

18 Salyut 6 cosmonauts conduct another experiment with the 'Kristall' furnace; they also carry out medical checks using the 'Chibis' pressure suit and the 'Polinom-2' equipment.

19 Third static test of Space Shuttle's Solid Rocket Booster (SRB) is completed at Thiokol Corporation's plant near Promontory, Utah. A main objective of the test – which ran the full two-minutes duration the motor must operate during launch – was to exercise the motor's thrust vector control using hydraulic servo-actuators to prove nozzle movement.

20 Engines of Progress 4 are used to raise orbit of Progress 4/Salyut 6/Soyuz 31 combination.

24 Soviets launch Intercosmos 18 into orbit of 407 x 768 km x 83 deg inclination; period 96.4 min. Satellite, which studies the "electrical interconnections between Earth's magnetic field and ionosphere," was developed by scientists from the USSR, Czechoslovakia, GDR, Hungary, Poland and Roumania.

[Continued overleaf

MEMBERSHIP DRIVE

With the opening of our new London headquarters in 1979, members will see tangible results of the Development Programme we began five years ago. We must now – as a matter of urgency – begin the task of building our membership to a new level which will ensure our future as a premier force in international Astronautics. We depend on a thriving membership to enlarge our effort and bring increased revenue to bear. Already we have seen an improvement in membership numbers as a result of initiatives taken by the BIS Council during the past 18 months. But the part that members can play in promoting the Society and bringing its work to the notice of others is our greatest strength. We are confident that all members will wish to join us in the effort to build a larger and still more effective BIS.

24 NASA launches 907 kg Nimbus 7 pollution monitoring satellite by two-stage Delta 2910 from Western Test Range, Lompoc, California, into 955 km high near-polar orbit.

24 Progress 4 is separated from the Salyut 6/Soyuz 31 combination by the on-board cosmonauts.

26 Progress 4 is made to re-enter atmosphere over the Pacific Ocean by radio command from Earth. Engines were switched on at 19 hr 28 min (Moscow time).

27 Salyut 6 cosmonauts "preparing for their return to Earth" conduct regular exercises in 'Chibis' vacuum suits. Suit includes closely fitting trousers of rubberised fabric. When air is pumped out, pressure is exerted on lower part of body increasing blood flow to the legs.

26 Soviets launch Cosmos 1045 and two piggy-back satellites Radio 1 and Radio 2 into orbit of 1,688 x 1,724 km inclined at 82.6 deg to equator; period 120.4 min. The two small satellites contain equipment for radio hams and experiments by students; both have the international registration index RS. Cosmos 1045 "carries equipment to continue the exploration of outer space, a radio system for the precise measurement of the elements of the orbit, a radio-telemetric system to relay data on instrument functioning back to Earth." Control of Radio 1 and Radio 2 "will be from ground receiving stations which also receive and process information. There will be a programme of communications sessions and the necessarily data is to be published."

30 Soviets launch Prognoz 7 into a high elliptical orbit of 483 x 202,965 km inclined at 65 deg to equator; period 98 hr 8 min. Satellite carries scientific equipment made in Hungary, Czechoslovakia, France, Sweden and USSR for research into the Sun's corpuscular and electromagnetic radiation, flows of solar plasma, magnetic fields in near-Earth space to determine effect of solar activity on the interplanetary medium and the Earth's magnetosphere; also instruments to study galactic ultra-violet and gamma radiation.

31 *Novosti* communiqué on the record-breaking flight of cosmonauts Kovalyonok and Ivanchenkov aboard Salyut 6 states that: "The Soviet space programme foresees the development in the 'Eighties of bigger space stations, with a life of up to fives years and between 12 and 24 cosmonauts on board, serviced not only by Soyuz and Progress spacecraft but also by a Soviet space shuttle, 'the Kosmolyot.' " (See *Spaceflight*, September-October 1978, pp. 322-326. Ed.).
Emphasising that Progress spacecraft have used their engines to push Salyut 6 back into a higher orbit, the statement says this is significant "because the big stations of the future will be assembled in space using this technique." In the 'Nineties Soviet scientists "are already looking forward to space stations with a life well over 10 years and with a crew of up to 120. These, in fact, would be real space factories and research institutes." Commenting on the current work of cosmonauts aboard Salyut 6, *Novosti* describes the largest piece of scientific equipment aboard Salyut as the sub-millimeter telescope nearly five feet in diameter. With this the cosmonauts "have looked deep into space, observed a lunar eclipse and investigated the Earth's ecologically important ozone layer." Salyut 6, the statement continues, is now being mothballed "to await the next cosmonauts, probably early next year. Hungarians, Bulgarians, Mongolians and Cubans are now in training for the next series of international space flights. It should not be long before there will be a permanently manned space station with long-stay crews relieving each other continuously."

30 A single Space Shuttle Main Engine is successfully static fired for more than 13 minutes to test its capability to return the Shuttle Orbiter to its landing site in case of a mission abort during launch. The engine operated continuously for 823 seconds, which is the longest burn time an engine should ever encounter during an actual Shuttle mission. Test was conducted at the National Space Technology Laboratories near Bay St. Louis, Missouri.

November

2 Cosmonauts Vladimir Kovalyonok and Alexander Ivanchenkov return to Earth in Soyuz 31 re-entry module after a record space flight lasting more than 139 days. They soft-landed 180 km south-east of Dzhezkazgan, Kazakhstan, at 14.05 hrs (Moscow time).

3 Skylab space station – previously flying with its docking module forward in the direction of flight, with the vehicle's long axis parallel to Earth's surface – is rotated 180 degrees because of low temperature conditions on one of the Control Moment Gyros resulting from periodic long-term shading from the Sun. Station will be restored to original low-drag attitude in April.

7 McDonnell Douglas Corporation announces receipt of first order for its new Payload Assist Module (PAM), a privately developed rocket vehicle that can operate from the cargo bay of the NASA Space Shuttle or as the upper stage of a conventional Delta booster. The order, valued at more than $16 million, was placed by Hughes Aircraft Company's Space and Communications Group and includes six PAMs. They will be used in the 1980s to propel satellites built by Hughes into high-altitude geostationary transfer orbits.

[Continued on page 10

BIS DEVELOPMENT PROGRAMME

AN APPEAL FOR HELP FROM MEMBERS WITH ARTISTIC ABILITIES

The Council would like to initiate a number of projects which would need to depend very heavily on participation by Society members with artistic or similar creative abilities.

We are seeking members with skills to help with such matters as, e.g.:–

(1) The preparation of sketches, plans, cutaways and other illustrations.

(2) To assist in design, by using expertise in the graphic arts.

(3) To undertake wholly creative work e.g. in originating designs for such things as badges, medallions and a new Society seal.

Members blessed with such talents and able to help are invited to write for fuller details to the Executive Secretary, adding particulars of specific skills or areas of interests as appropriate.

CONCRETE SPACE COLONIES

By Dr. D.J. Sheppard

Introduction

Space Colonies are unlike any other structures. They are difficult to design because they lie beyond our experience in many areas. Since extrapolation is the commonest cause of unsafe design, it will be essential to use proven technology wherever possible. There is enough scope for disaster without looking for trouble by using adventurous ideas where they are not necessary.

But can we reach agreement on what constitutes "proven technology"? An aerospace engineer would claim that Space Colonies are merely overgrown spacecraft, so there is no problem. The inadequacy of this approach is illustrated by Fig. 1, which shows the characteristic range of mass and lifespan for several types of structure. This chart helps to put Space Colonies into perspective – they are vastly larger and longer-lasting than anything produced by high technology. A factor of ten thousand separates the largest airliner from the smallest Space Colony. Quite clearly, such a gap can only be bridged by many generations of extrapolation.

The Kingdom of Concrete and Rock

The other 'proven technology' has amassed 10^{16} hours of experience in large space structures. It is represented by the planets, moons and asteroids of the Solar System. This technology depends on the compressive strength of rock prestressed by gravity. Tensile metals are not present. When designing Space Colonies we should pay attention to the possibility of using compressive structures. Returning to Fig. 1, it will be seen that different materials suit different sizes of structure. Up to a few hundred tonnes, the designer has a choice of many materials including aluminium alloys. Steel and concrete compete in the middle range up to one hundred thousand tonnes. But concrete is the only suitable material for really big, long-lasting structures comparable with Space Colonies. The largest mobile structure ever built is the half-million tonne Ninian Central oil platform built in Scotland; this uses prestressed concrete. Some reinforced concrete dams weigh more than twenty million tonnes, yet the largest metal structure scarcely exceeds one hundred thousand tonnes.

Concrete is a compressive material made of rock, so man-made technology has reached the same conclusions as Mother Nature. Can anyone deny that Space Colonies belong to the kingdom of concrete and rock, far above the small, ephemeral world of rockets, jumbo-jets and supertankers?

The objection may now be raised that Space Colonies are

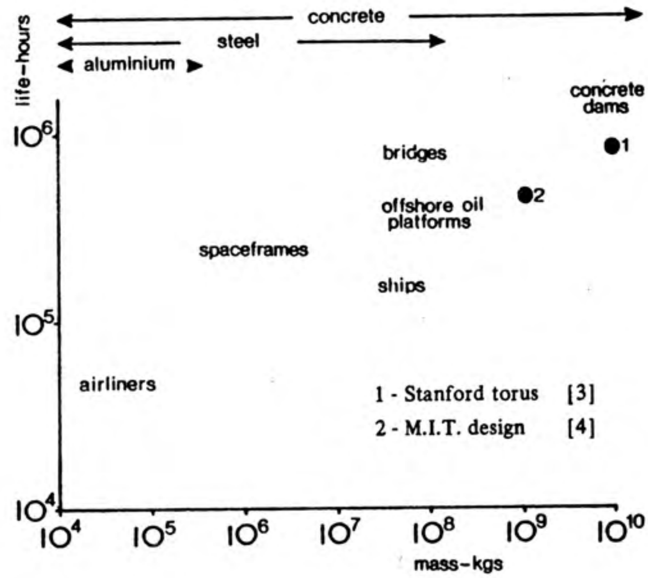
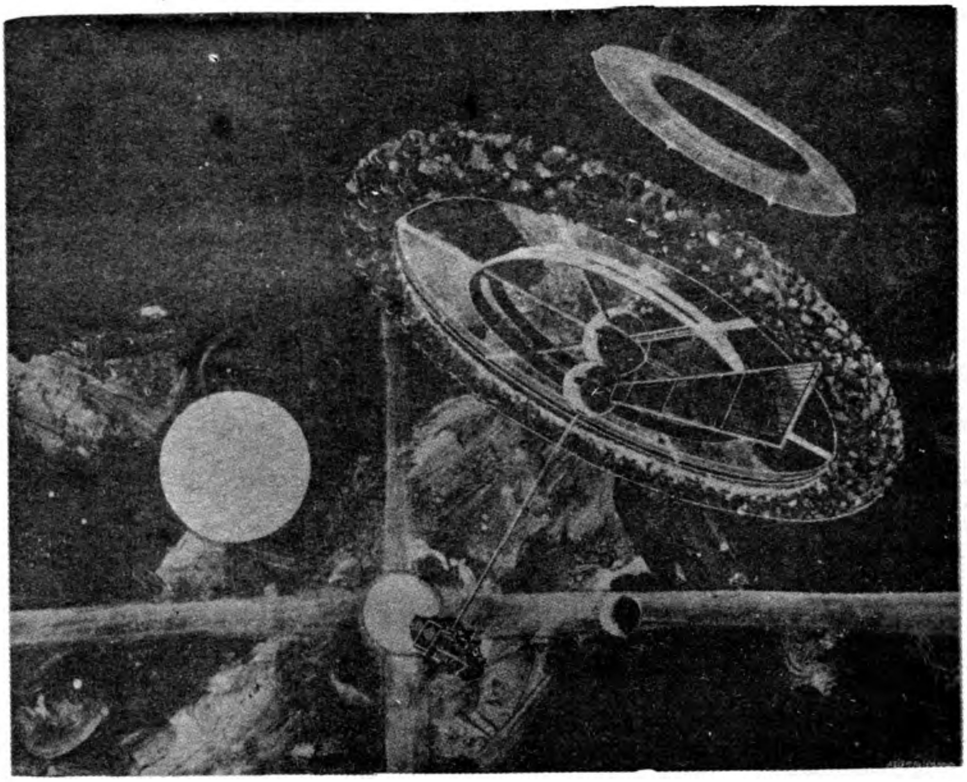


Fig. 1. Characteristic range of mass and lifespan for several types of structure.

SPACE COLONY for 10,000 people based on the 'Stanford Torus.' The wheel-like colony would be over a mile across, with an interior diameter of about 600 ft (183 m). Gravity would be simulated by centrifugal force from the structure's 1 rpm rotation. The mirror above the colony reflects sunlight for lighting and agriculture. The long rectangle in the foreground is a heat radiator, and the facility below the colony is the manufacturing area where lunar ore is melted with solar power. The massive exterior of Moon rocks is meant to shield the inhabitants from cosmic radiation.

NASA



high-performance structures, unsuited to a "crude" material like concrete. In fact, concrete is the best high-performance material for all applications where mass is not critical; it is the best material for liquid gas ships [5], huge oil platforms in stormy seas, and large test vessels containing 10,000 psi or 69 N/mm^2. For nuclear reactor vessels, concrete "has been demonstrated to have the potential for unparalleled inherent safety characteristics." [6] In recent years, old-fashioned civil engineers have started to lament the disappearance of steel as the last remaining rival of ubiquitous concrete. Its use is now being extended into mechanical engineering, where it is a superior material for cast components such as machine tool bodies.

And a Space Colony is not mass-critical, since its total mass is fixed by shielding requirements. A typical "metal" design is more than 90% rock and less than 10% metal; this happens to be the ideal recipe for making prestressed concrete. None of the published proposals for Space Colonies [1, 2, 3, 4] has recognised that a variety of prestressed concrete is the ideal form of construction, because it has relevance, proven capabilities, economy, safety and simplicity. The possibilities will now be investigated.

The Secrets of Prestressed Concrete

We all know that concrete, rock and glass are weak in tension but strong in compression. Such materials make excellent structures provided they remain in compression – just think of pyramids and cathedrals. Gravity compresses these structures so strongly that tensile stresses never occur during service.

In recent years, civil engineers have discovered how to apply the same principle to high-performance concrete. The secret is to impose a permanent squash during construction. Tensile forces can then be added without producing tensile stresses. As tension increases, the concrete becomes less compressed but does not become tensile under normal loading. This sounds too good to be true, and it must be paid for by the extra effort needed to squash or 'prestress' the concrete. This prestressing operation involves tensioning a number of steel cables stretched between anchorages at the ends of the concrete.

Since the cables or 'tendons' have to withstand both prestressing and service loads, it may not be clear where the economy lies. The secret is the very high stress that can be borne by steel cables – common civil engineering accepts working stresses of 1100 to 1600 N/mm^2 which is about six times as much as for plating or rolled sections (see Table 1). Even though prestressed concrete involves bigger forces, it requires less steel than an equivalent all-steel structure. And it has other advantages.

Prestressed Concrete for Space Colonies

Accepting that prestressed concrete should be relevant to the Colony design problem, we still need to show it is feasible and economical for use in Space. This requires the reader to take a long view of Space technology and avoid limiting his thinking to the restricted range of techniques familiar to the aerospace industry.

On Earth we make concrete from sedimentary rock, water, heat, sand and pebbles. In Space we will use fused rock from the Moon. This behaves like concrete but is much stronger. As on Earth, the other component will be steel reinforcement; in this case extracted from lunar rock.

The current recipe for Space Colonies calls for three materials: metal for structural strength and stiffness, rock for shielding, and glass for transparency. Our new prestressed concrete design uses the same mass of rock, less metal, and as much glass. Instead of being restricted to one material, the functions of strength, stiffness, shielding and transparency are shared by the rock, metal and glass. The new design is simpler, cheaper and more elegant than the alternatives.

To illustrate the structural economy of prestressed concrete, Table 1 compares several designs for a toroidal Space Colony based on the "Stanford Torus" [3], but modified in the light of more recent studies [4]. This design has a single-skinned hull, an internal shield and a primary structure of steel. The materials and stresses in Table 1 have been extracted from various codes of practice for large pressure vessels in nuclear, marine and mechanical engineering [7, 8, 9, 10].

From Table 1 it will be seen that the concrete design uses less than one third as much steel as the cheapest all-metal design. The absolute masses are not important because they relate to conservative design, although they do illustrate the limitations of current technology. Space Colonies will need something better. It seems reasonable to expect that wire and plate will both be developed in stronger forms, so prestressed concrete should retain its structural advantage for building Space Colonies.

Table 2 shows the stresses in concrete and cables at various stages during the construction and use of the concrete colony. It will be noted that the concrete is never stressed above 10% of the strength attained by fused rock (400 N/mm^2). Despite the uncertainties of casting and prestressing large blocks of fused rock, this material should be very dependable.

Fig. 2 shows the structural detail of a prestressed concrete Space Colony. A "building-block" system has been used, in line with current practice for building large bridges and oil platforms. The basic unit of construction is a rectangular slab of fused rock 1.6 metres thick. Passing through the slab is an orthogonal network of ducts for the prestressing cables. Each slab forms one sector of a ring which is itself a sector of the complete toroid. The size of each slab is a compromise between the small size that is best for casting and the large size that simplifies assembly. At present we will guess that a one thousand tonne slab, 17 x 13 metres, might be

TABLE 1. Mass of Steel Needed for Stanford Torus Designed with Current Technology

Form of Structure	Basis	Ultimate Stress N/mm^2	Working Stress N/mm^2	Mass of Steel Tonnes
Tensile Steel	BS1500 (9)	600	128	11,057,000
Tensile Steel	Lloyd's Rules (10)	610	190	5,627,000
Tensile Steel	ASME III (7)	690	230	4,273,000
Tensile Steel	MIT Study (4)	1380	245	3,919,000
Prestressed Concrete	ASME III (7)	1700	1105	1,148,000
Prestressed Concrete	BS4975 (8)	1700	1105	1,242,000

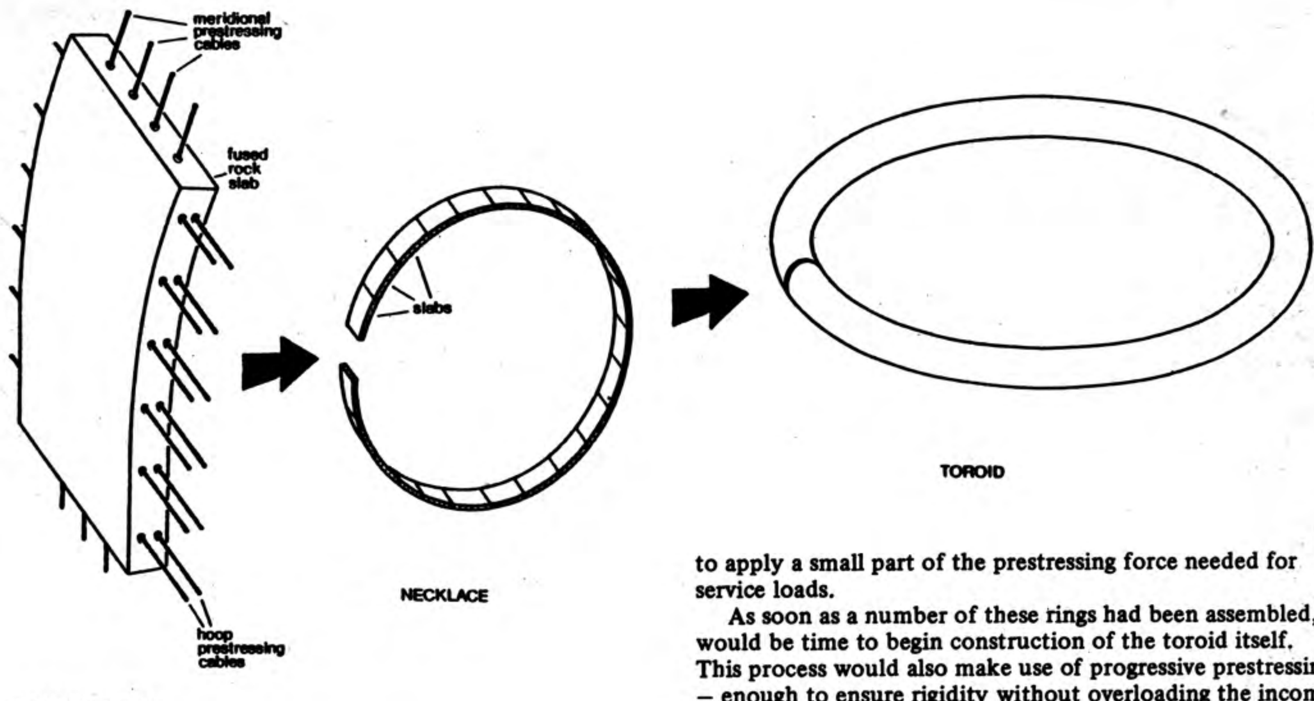


Fig. 2. Structural detail of a prestressed concrete Space Colony. Basic construction unit is a rectangular slab of fused rock 1.6 metres thick.

suitable. Even using such large slabs, the colony still needs 10,000 of them. One big unknown is the technology of casting large slabs like this, and of forming the necessary ducts and profiles within the slabs. In space the micro-gravity and low cooling rate would help to prevent problems, but this might involve large numbers of moulds because of the lengthy cooling period for each one. Several techniques could be used for forming the ducts. Diamond drilling, cast-in ducts and withdrawable moulds are among the possibilities.

The construction process would start with a necklace of slabs making up one ring of the toroid. Meridional prestressing cables would form the 'string' of the necklace, although each cable would only extend part of the way around the circumference and would be anchored within the hull. Progressive prestressing of these cables would gradually lock the slabs into a rigid ring, aided by epoxy mortar on the joints between them. At this stage it would only be necessary to apply a small part of the prestressing force needed for service loads.

As soon as a number of these rings had been assembled, it would be time to begin construction of the toroid itself. This process would also make use of progressive prestressing – enough to ensure rigidity without overloading the incomplete structure. Finally, when the toroid was complete, all the cables would be "tuned" up to their final working loads.

It will be noted that a fused rock hull provides strength, stiffness and shielding properties. There are two possible ways of providing light transmission. Following the scheme used for the Stanford Torus, windows would consist of thin panes held within a strong windowframe. The function of the windowframe is to maintain the structural continuity of the hull; it is an obvious source of weakness and inefficiency. Since the hull of the concrete design is well understressed, this type of window could be adopted by concentrating the cables within narrow concrete ribs in the frame. Alternatively, the concrete design could make use of the high compressive strength of glass to form part of the main structure. The windows would now consist of thick slabs, or thick laminations of panes of glass with the same thickness as the concrete hull. Thus, the concrete and glass would form a continuous compressive structure with great strength and rigidity. Furthermore, these glass windows would give complete protection against radiation without needing the complicated "chevrons" and mirrors proposed elsewhere [3]. Although simple and elegant, the second design has two limiting features that may prevent its use. Firstly, it requires large

TABLE 2. Stresses During Life of Prestressed Concrete Design

Condition	Load Factor	Steel Stress N/mm²	% of Ultimate Steel Stress	Concrete Stress N/mm²	% of Ultimate Concrete Stress
Prestress	0	976	57%	40	10%
Prestress (after losses)	0	832	49%	34	9%
Normal Load	1.0	985	58%	15	4%
Design Load	1.1	1000	59%	13	3%
Warning Leak	1.75	1105	65%	0	0%
Damage Load	2.18	1360	80%	0	0%
Ultimate Load	2.75	1700	100%	0	0%

amounts of glass – perhaps seventy times as much as the alternative design. Since glass will be more difficult to make than rock slabs, this will be an expensive feature. Secondly, it will be necessary to produce silica glass that is both very thick and very transparent, and it must be admitted that current technology does not allow the production of slabs of optical glass 1.6 metres thick. Despite these limitations, it would be a fine thing to build a transparent, smooth-skinned Space Colony instead of the blind, slag-covered alternative.

From this brief description it will be seen that the technology of prestressed concrete is adaptable for use in Space Colonies. There are several areas of uncertainty about the use of fused rock and glass, but the concept does draw on techniques proved on very big structures on Earth.

Safety

A large Space Colony would be expected to last at least a century without threatening structural failure; and this includes collisions, industrial accidents, sabotage and other hazards familiar to low technology. Even by turning a blind eye to many accidents, aircraft designers have to admit one disaster in a million hours. This means that a high-technology Space Colony would be likely to fail structurally during its one million hours of operation. Current space technology would be even less reliable. It must be conceded that Space Colonies require several orders of magnitude improvement over the level of safety so far achieved by the technology normally proposed.

One should perhaps be aiming for the level of safety achieved by nuclear reactor vessels, where structural integrity must be preserved at all costs. Quoting once again: "It is somewhat inconsistent that during a period of almost overwhelming public concern for reactor safety, prestressed concrete reactor vessels have not come into more widespread use for all types of reactors" [6]. For "reactor" read "Space Colony". Prestressed concrete is safer on six counts:

(1) A compressive pressure vessel is fundamentally safe because holes and cracks have no reason to propagate. An all-metal vessel is like a large balloon which tends to go "pop" if it is pricked. To prevent sudden rupture it is necessary to restrict tensile stresses and to include a network of crack-stoppers in the hull. A continuing programme of inspection is also needed throughout the working life of the structure. In contrast, a compressive hull can be thoroughly cracked without losing strength or safety.

(2) The strength of prestressed concrete depends on a multitude of separate cables. Several can break without compromising overall strength. An all-tensile design can only provide a low degree of structural redundancy by the complicated expedient of using a double or triple hull.

(3) Prestressed concrete pressure vessels have a natural leak-before-failure behaviour. If overload occurs, the stress in the concrete reduces to zero, and the joints and cracks begin to open and allow detectable leakage. At this stage the cables still behave elastically, so there is plenty of warning before permanent damage or failure can occur. In contrast, it is difficult to arrange for a metal pressure vessel to give much warning of failure, as witness the horrifying accidents that do happen. This leak-before-failure requirement has been shown to place severe restrictions on the design of Space Colonies, for example eliminating aluminium as an alternative to steel [4].

(4) Prestressed concrete can easily be tested during construction, allowing great confidence to be placed in the materials used. The concrete (fused rock) is most highly stressed after prestressing, as shown in Table 2. This makes it possible to detect and replace weak material during construction. Although the cables are worst stressed at maximum overload, their strength can be checked during manufacture. It is possible to proof-test every piece of cable in its operating mode – uniaxial tension – as part of the production process. The best that can be done for a metal hull is to test a few samples and pray that uniaxial proof tests mean something for triaxially-stressed plating. The high degree of confidence provided by cables is one reason why their allowable stress is so high.

(5) Concrete is inert and long-lasting. A metal hull would be exposed to the corrosive internal atmosphere, vacuum, thermal cycles, radiation, fire, impact and other accidents. These influences would gradually damage the strength and integrity of the hull. In contrast, a fused rock hull would be immune to most influences, the material having survived several billion years on the Moon without changing. Perhaps the rock might become weathered in contact with air, but its low stressing would permit the loss of much of its structural depth. The prestressing cables would benefit from being deep within the concrete, where they would be protected from most harmful influences. If necessary, it would be possible to immerse the cables in preservative.

(6) Prestressed concrete is easier to maintain. Since there are very many cables it is possible to remove a proportion for testing at any time. If satisfactory, the cables can be put back; if they fail the test then new cables can be substituted. And this can be done from the access points at the anchorages within the hull. Since fused rock is practically inert, there will be little need for maintenance of it. Where this is necessary, the repair can be a "glue-job" using epoxy concrete. No equivalent process is possible for a metal hull, and one can imagine the problem of replacing a plate on the "underside" of a rotating colony. Because the concrete design is easier to check and maintain, its long-term safety should be assured. We can think in terms of a thousand-year colony, like a cathedral in the sky.

With a metal hull one could only hope for a hundred-year life. After all, steel has not been invented long enough to tell us how it behaves past its first century.

Faced with these remarkable advantages for prestressed concrete, one can see why metal Space Colonies would need to pay higher insurance premiums.

Economics

The lifetime cost of a Space Colony is the sum of several costs such as Research and Development, materials, construction equipment, labour and maintenance. At our present state of innocence, it is pointless to present a list of absolute costs; but it should be possible to show the relative advantages of metal and concrete colonies.

(i) Research and Development

The technology of metal Space Colonies is entirely new. Nothing comparable has been built on Earth, and probably never will be because metal is not suitable for structures with this size and lifespan. Lacking experience and prototypes, the R & D bill for a metal Space Colony is certain to be enormous. It has already been noted

that concrete has proved itself in structures of the required size. So one unknown has been removed. Further advances could be made by building a prototype from lightweight concrete and testing the construction process underwater. This knowledge would reduce the uncertainties in the structural design, and would reduce the Research and Development needed for the prestressed concrete Space Colony.

(ii) *Materials*
Since radiation shielding is the most critical factor in the design of a Space Colony, both metal and concrete designs require the same mass of rock exporting from the Moon. Other materials must be exported from Earth. Chief among these are the alloying elements needed to make strong steel from the weak iron extracted from lunar rock. We have already shown that a prestressed concrete colony needs less steel than an all-metal colony. But prestressing cable is also more economical in alloying elements than the alloy steel needed for crack-stopping plates. Therefore a concrete colony would need only a fraction of the imported elements required for a metal colony. Both types of colony would use consumables during construction. A metal colony will need painting internally at least, and the welding process may involve extra materials. Being permeable, a concrete hull would need an airtight coating on the inside. Some epoxy resin would be used to join the slabs during construction. At this state of knowledge there is no obvious difference in the use of consumables, but a concrete colony has a clear overall advantage in material imported from Earth.

(iii) *Equipment*
Both designs require furnaces and smelters for making steel from lunar rock. Since it is much easier to make cable than to roll and form plating, the prestressed concrete design will require less equipment for the steel production process. Both designs also use fused rock, although the concrete colony needs a more refined version. The metal hull requires a large amount of welding and inspection equipment, whereas prestressing needs only a few jacks. Finally, both designs use formwork and cranes of some description. Added together, the equipment for prestressed concrete colonies would probably be lighter, and would certainly be simpler.

(iv) *Labour*
For the prestressed concrete colony, the amount of labour to make components will be reduced in line with the simplicity and reduced scale of the extraction and manufacturing processes. It is difficult to compare the labour needed to assemble the components, but terrestrial experience suggests that the prestressing operation would be easier than the alternative welding procedure. In terms of inspection, prestressed concrete would use much less labour because its faults are easier to spot yet less critical. So far we have only referred to "labour" in the inhuman economic sense. The workers themselves would award concrete bonus points because of its shielding qualities – a partly-built concrete colony provides complete radiation protection, whereas a partly-built metal colony may even make it worse. Although, labour is the least definable factor, it is unlikely that a prestressed concrete colony would use as much manpower during construction as a metal colony would use.

(v) *Maintenance*
It has already been pointed out that a Space Colony built of stone is likely to last much longer than a colony built of steel or other metal plating. Put another way, the structure of a prestressed concrete colony would need much less maintenance to achieve the same standard of safety. Corrosion would be more of a problem with a steel colony, and one can imagine an ecological hazard due to the continuous painting of the inside skin. Where repairs are necessary, the thick-skinned concrete colony could probably be plugged from the inside, whereas a metal skin would be most accessible from the dangerous outer surface. Maintenance is an area where prestressed concrete is clearly superior to metal, as one could have deduced by looking at structures on Earth.

This list of economic factors may be superficial, but it does indicate that a prestressed concrete Space Colony would be most unlikely to cost as much as a conventional metal colony. It would probably be very much cheaper.

Architecture

Would you prefer to live in a concrete colony or a metal colony? Does the type of structure make any difference to the occupants? The answer is obviously "yes" – just compare a church with an oil tank of the same size. Metal is cold, slippery, noisy, vibrating, and generally insecure and unsympathetic. Rock is solid, acoustically splendid and reassuringly familiar. Because of its low thermal conductivity, rock maintains an even surface temperature, while its great exposed area transmits waste heat more efficiently than a metal structure. The fire resistance of rock is incomparably superior, which is why steel structures are clad in concrete or processed rock. Surprisingly enough, the resistance to impact and explosion is also greater, if military experience is any guide [5]. So a prestressed concrete colony is more robust. No amount of mistreatment or incautious architecture is likely to damage it internally. Unlike a metal colony which could easily be damaged either intentionally or accidentally.

This robustness allows more freedom to the architect to design the inside surface of the structure, perhaps emulating the soaring fan vaults of mediaeval stone architecture. On an individual scale, the strength of a concrete colony would be great enough to cope with local decoration and carvings. Psychologically there is a lot to be said in favour of a rock-solid floor 1.6 metres thick. Combine this with the ambience of a vast airy cathedral, and it will be agreed that prestressed concrete is the most favourable material architecturally.

Internal structures could easily be bolted into a rock hull, because the surface layer is not essential for structural strength. Compare this with the problems that occur when bits are welded on to high-strength steelwork. One can even imagine an enthusiastic do-it-yourself colonist drilling right through the thin metal skin while trying to fix up a shelf. Concrete is more fool-proof because it is thicker and inert to most influences. From the architect's viewpoint, concrete is best.

Conclusions

It seems that prestressed concrete is the best material for building a Space Colony because it is a proven material for the largest structures and because it is safer, cheaper, simpler and more suitable than any other material. If one considers, space structures more generally, it can be claimed that concrete is the most appropriate material for any "static" structure whose raw material is rock. Thus, any structures built at L5 using rock shot from the Moon should be concrete structures making use of both the processed metal and the resulting slag. This goes against the traditional assumption that satellites and orbiting power stations should be delicate metal frameworks. Concrete is best for a wide range of structures in space.

Although the reader may not go all the way with these arguments, there should be an obvious question in his mind. Since prestressed concrete is arguably a good material for Space Colonies, why have we never heard of it before? To

answer that it is necessary to remember that logic is not the only determinant of engineering design. In Europe the intense competition between steel and concrete has led to cheap and efficient designs in both materials. In the USA, however, the different cost equation favours steel, so concrete has languished. So much so that steel is often the only material considered for applications where concrete would be better. Perhaps this is what happened with Space Colonies.

A recent report stated confidently "For economy in structural mass it is essential that large shells holding gas at some pressure must act as membranes in pure tension." [3]. Any European civil engineer would spot the fallacy in that claim. This oversight illustrates the need for pooling techniques from every field of engineering, and from every nation. It is hoped that the present work has shown how low-technology ideas can beat the best of high technology.

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"AND LESSER MOONS HAVE SMALLER MOONS..."

By Anthony T. Lawton

Introduction

I.A.U. Circular 3241 which carried news of a satellite of Pluto [1, 2] also had details of another 'first' – a satellite of a minor planet! This surprising find was the result of observations made on 7 June 1978 by E. Bowell and M. A. A'Hearn of Lowell Observatory, J. McMahon (near Boron, California) and K. Horne (near Rosamond, California). The observers were expecting the minor planet (No. 532) *Herculina* to occult the star SAO 120774 and thereby more accurately determine its diameter – assuming it is a spherical planetoid body.

A Surprise Bonus

The occultation date and time had been predicted by G. E. Taylor and D. W. Dunham of the Royal Greenwich Observatory. Taylor has been responsible for a number of successful occultation predictions including that by Uranus, observations of which led to the discovery of the rings of Uranus.

Precise forecasting is not easy when dealing with very small objects like minor planets but it was hoped that the shallow belt has been delineated with sufficient accuracy for a successful series of observations. This was done and has established the diameter of *Herculina* as 217 ± 3 km (approximately 135 ± 2 miles)

But the observations produced a surprise bonus in the form of a *second* occultation which has been presently interpreted as due to a satellite 50 km (31 miles) in diameter orbiting at a distance of 975 ± 1 km (approximately 610 miles). Of course it is not known whether the orbit is circular or elliptical, but the observers point out that if the satellite [temporarily designated 1978 (532), in accordance with I.A.U. nomenclature] is of similar composition to the main body, then it will be three magnitudes fainter. As such, the object should be visible and capable of being photographed by several telescopes. An accurate orbit could therefore be determined and additional information gained in terms of accurately determining the mass of *Herculina*.

The planetoid has had its diameter measured to an accuracy better than 1.5% and an accurate mass assessment would therefore lead to an accurate *density* determination – the first for a body in the minor planet category. This is important, for several reasons. We suspect that the minor planet belt is a transition region between the small, dense inner planets which are mostly composed of rock and metals, and the large low density outer giants which are largely made up of hydrogen and hydrogenous compounds (methane, ammonia, etc.).

We know that the belt *is* a "no-man's land" which marks the sharp *density* transition between the inner planets (typical density 5.5) and the outer planets (typical density 1.5 to 2.0). If we assume that meteoric material is also typical of the minor planet constituent material, then we should expect an amorphous mixture of iron, stony and carbonaceous bodies. The preponderance should be stony with a density of between three and four and this should be typical of *Herculina*. But one good measurement is worth a thousand theories, and in this case it is being offered on a plate!

This double occultation by a twin planetoid system is unique and the chances of the satellite orbiting in the occultation plane are so low as to be almost suspicious! I would therefore suggest that possibly it is a *ring* which is surrounding *Herculina* that caused the observed effect. In making this suggestion, I am aware that a ring would be expected to produce a symmetrical triple occultation (one minor, one major, a second minor, in that order). That this was not observed does not entirely rule out a ring system, for the line of sight and the occultation movement may not be symmetrical.

Further observation of *Herculina* is therefore required in order to obtain more information on this micro Solar System.

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SURVIVAL - OF WHAT AND WHY?

By G.W. Wood

Introduction

Among the forseeable long term consequences of space activity, perhaps the most important is the enhanced probability of survival of some catastrophe, brought about by not being where the catastrophe is. I have just purposely avoided stating the survival of what, though when others consider this possibility they usually refer to the survival of humanity, the species or human culture. I propose in this article to consider the question posed in the title.

Of What?

Survival has been taken to mean different things. Dictionary definitions include reference to the continuation of existence and remaining unaffected by events. Mach said that everything in the Universe affects everything else. Therefore nothing can exist without the Universe being different, because of its existence, from that which would otherwise have been the case. Thus a thing may cease to exist but its effects continue to exist. Let this, for convenience, be called the survival of effects.

Another form of survival is, as in the dictionary definition, the continuation of the existence of the thing itself in an unchanged, or virtually unchanged form. This is the kind of survival enjoyed by rocks, for instance. The effects of a rock will also survive, of course.

Biological survival is a complex phenomenon possessing elements of the two forms already described, yet adding to them. The survival of effects is obvious, while the second type of survival, that of the thing itself in a virtually unchanged form, applies in its strictest form in certain biological cases such as freeze dried bacteria or the cryptobiotic states of certain nematodes, tardigrades and rotifers, where there may be no detectable metabolism. In most cases of life on Earth the survival of the thing itself applies in a looser form than that so far described. This is because organisms are in a constant state of flux, their structures subject to constant degradation and reformation such that an individual may be considered to be the same from one year to the next yet be composed of largely different basic parts. Even if the trivial difference between one carbon atom and another is ignored, yet still individuals are constantly changing in the nature of their components, their proportions of one part to another or in the case of creatures which metamorphose, their entire form. Thus biological survival involves change. Such biological development involves the differential expression of genes in time. The organism is genetically the same throughout its life, only its phenotype changing.

During reproduction, the genetic information of the parent survives wholly or partially in its offspring, depending on whether the reproduction is vegetative or sexual. In the former case, particularly where binary fission is involved as in bacteria or in some algae and protozoa, organisms are often said to be immortalised. In the latter case individual genes are 'immortal' but the particular combinations of genes that form organisms are not. Over a longer time scale, that of biological evolution, the role of change in survival is seen more strongly. Thoday [1] has described well the antithesis between the needs for genetic stability, to ensure that offspring will be viable, and variability, to provide the variety on which selection may act, since in the event of environmental change, staying exactly the same may be a disadvantage. It is unlikely that the original genes which appeared on Earth have survived to the present. They would have been too inefficient in competition with later variants of themselves, and conditions have changed since the postulated primaeval soup. But though their information has been lost, it is not as if they had never existed. Obviously as already stated, their effects survive, but when the word effects is used here it does not just mean in the weak sense already described for rocks but also in a much stronger sense. The latter, stronger sense of survival of effects is that of effects which still interact with each other. Thus a tree may be considered as an effect of an ancestral photo-synthetic unicellular organism, since if the latter had not existed then neither would the former exist now.

All life on Earth may thus be considered as a surviving effect of the original genes. Similarly, but on a shorter time scale, if the molecules of an organism are all turned over then the arrangement of the new molecules is an effect of the arrangement of the previous ones. The new molecules do not spontaneously come together to form an organism. Let this type of survival, which is found in biology, be called the survival of organised effects, though the words concentrated or structured may be used in place of, or in addition to, organised. This is in contrast with the survival of effects originally described where the effects tend to be dissipated, such as the light reflected by a crystal or the wind eddies caused by a cliff.

In most terrestrial organisms other than humans, the survival of the organised effects of an individual depends on participation in the production of offspring, either as parents or by non-parental assistance of kin, as is performed by the sterile worker castes of hymenoptera, for instance [2]. Culture provides an alternative for the survival of organised effects. Simple cultural transmission has been described in Japanese Macaques [3,4] relating to food washing and separation and in Chimpanzees [5] relating to the use of tools. Human culture, which possibly started with the transmission of skills of a similar nature, has developed into the vast areas of art, technology, language and science. A human being who transmits a skill, creates a work of art, patents an idea or builds a road is producing an organised effect which may well survive him. The long term survival of cultural organised effects depends on the survival of the society affected by them, and with the increasingly evident interelationship of all societies on Earth, one could expand this to be the survival of humanity..

As stated in the introduction, this is where many would leave it. The survival of a person's organised effects, genetic and/or cultural, is dependant on the survival of humanity. Some would take it further. One of the organised effects of humanity may be that which replaces it, either in the form of genetically improved human beings or of self-maintaining and replicating artificial intelligences. These concepts are controversial, particularly the latter. The gap between human brains and current computers is very large and there appear to be fundamental differences in processing of information, such as the brains use of parallel processing to a greater degree than is the case with computers or the lack of ability of the latter to regard information with respect to an internal world model [6]. However, I consider the human brain to be a mechanism, and not one with a ghost inside. The mechanism is admittedly plastic in its capabilities and the software is very sophisticated but it is a mechanism nonetheless. Unless the human brain is the only possible sentient mechanism which can be achieved within the basic universal laws, which is, I think, an arrogant anthropocentric view, then it is likely that other, different mechanisms could be produced which would be capable of surpassing human intelligence.

Such superior intelligences may be a better bet for the long survival of organised human effects than humans themselves. They may, for instance, by easing the limitations imposed by human frailty and timescale (and possibly inclination), make interstellar space travel a relatively simple proposition.

Why?

Why should one wish to survive or wish for ones organised effects to survive? Animals, including humans, desire survival, or to put this in a behaviourist sense, they behave in such a way as to enhance the probability of their survival, because they are the offspring of animals which displayed similar behaviour and consequently lasted long enough to reproduce. Behaviour which does not allow survival is not inherited. There are examples of behaviour which is self sacrificing, but this is usually explained, by inclusive fitness theory, as being behaviour which enhances the likelihood of survival of kin which have genes in common with the sacrificed individual, thus increasing the overall survival probability of these shared genes. This answers the question of, "Why survive?", in a mechanistic sense, but one is left with the other sense of why, which is that of having a reason for choosing to survive. This aspect of the question of survival is perhaps best illustrated by its negative side, the despairing, "What is the point of it all?", when faced as an individual with certain defeat at the hands of death, or, even if one can think beyond this personal death, with the prospect of one's organised effects in humanity carrying on surviving for survivals sake until either entropy or some more sudden catastrophe destroys a thing which has never found a satisfactory raison d'etre.

Transience of either a personal nature or of humanity as a whole is a thing which humans find difficult to accept. It is the setting of limits to survival which often brings one to question the purpose of any survival at all, people finding it quite easy to carry on in pointless hedonism until pulled up by the unpleasant reality of death. Personal survival can retain purpose despite the accepted inevitability of death by the production of genetic or cultural resources which will survive in society after death. Some, indeed many, not finding this enough deny their personal transience and believe in some aspect of themselves which will transcend the limitations of the material world to find eternal life in some type of beyond. Life after death is a powerful feature of many religions, but it would be unduly cynical to say it was only put there to attract those afraid of death, since an afterlife may be as much of a threat as a promise, as in the ethical reward and punishment, heaven and hell, type of religions; or it may simply be a rather unpleasant prospect as in the case of the Sumerians whose souls would grow feathers and eat dust.

As well as delaying the necessity of answering the question, "Why survive?", by promising to overcome the transience of personal survival, religions may try to provide a final purpose for existence. This may simply consist of saying that there is a final purpose and the god in question knows what it is, while humans are too simple to be able to grasp it so they must just be faithful. Sometimes a kind of mystic unification with the rest of the Universe is involved, though quite why this is advantageous is never clearly defined.

If one can accept personal extinction and the survival of one's organised effects in humanity as a whole then there is still the transience problem on a far longer timescale. Even if all other cosmic disasters are survived there is still the prospect for intelligence of either heat death in an open universe or collapse to an information destroying singularity in a closed one. There has been speculation that these limits may be overcome [7] and such speculation, I suppose, illustrates again the fact that we are happy with pointlessness as long as it is limitless pointlessness. However, if there is to be no overcoming of these limits, is there any point to survival? Possibly we should survive long enough to allow intelligence to develop to the point at which it would understand the purpose of the whole thing, be satisfied and then cease to exist. The final organised effect of our existence would be an omniscient intelligence as difficult for us to understand now as the gods which religions offer us. We would have to rely on faith again, though perhaps not such blind faith as religions call for since it is not unreasonable to think that knowledge and the ability to understand and correlate it will increase. This prospect of there being an ultimate satisfaction which calls for no further survival of that which is feeling satisfied is odd, but the idea of internal satisfaction which has no further external purpose is inevitable if one thinks far enough. The Universe, by definition, includes everything and any satisfaction it gives must be self satisfaction. This smug universe idea may be the ultimate in pointlessness.

To return to the present situation of humanity, there is the argument for survival that if there is anything to survive for then it is good that we try to do so, and if there isn't, then it doesn't matter if we try to do so. Not trying may be a mistake while trying may be right and can't be wrong, just pointless, which is different. Some may argue that survival at all costs is wrong and that at some point, or degree of effort, we should accept extinction with dignity and without necessarily understanding what it had all been about. Those who decide not to survive are, however, never around very long to put their case. Suicide is self defeating, both personally and as a philosophical argument.

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MILESTONES / *Continued from page 2]*

8 Institute for Surveying Natural Resources from Outer Space is set up in Baku, capital of Azerbaijan. Multi-spectral photographs taken from satellites and space stations "will make it possible to keep continuous watch on vast tracts of land."

WHERE ARE THEY NOW?

By David J. Shayler

PART THREE

Continued from September-October 1978 issue p. 330]

Group 5. Pilot Astronauts: 19 selected, 4 April 1966

The fifth call for astronauts was issued by NASA on 10 September 1965; similar requirements were listed as for the Group 3 candidates, except the age limit was extended. Total applications received was 351 of whom 159 met the basic requirements, 100 being military personnel, the others civilians. Following the usual screening procedures a total of 19 applicants were chosen to form NASA's fifth group of astronauts.

The Astronauts:

BRAND, Vance D., Civilian. Born 9 May 1931, Longmont, Colorado. Married, four children. Assigned crew member for the Command Module prototype (Apollo) thermal vacuum testing; astronaut support team member Apollo 8 and Apollo 13; backup CMP Apollo 15; eligible to fly CMP Apollo 18 before that mission was cancelled due to lack of funds. Backup Cdr Skylab 3 and 4; named Cdr of Rescue Skylab CSM, which was nearly launched during the Skylab 3 mission July-Sep. 1973, CMP Apollo 18 (ASTP) 15-24 July 1975, one of the most experienced astronauts concerning Apollo type CSM assignments/systems. Subsequently assigned to Space Shuttle Development; April 1978, named as one of the group of astronauts assigned to fly the Space Shuttle in its Earth orbital test programme, which involves six manned orbital missions in 1979-80.

BULL, John S.Lt Cdr USN (Ret.). Born 25 September 1935, Memphis, Tennessee. Married, one child. Forced to withdraw from both the Astronaut programme and USN July 1968 due to rare pulmonary disease, subsequently employed in Aircraft Guidance and Navigation Branch, NASA's Ames Research Center Moffett Field, California, as Research Scientist, a position he still holds at the time of writing; he is also currently working towards a doctorate at Stanford University.

CARR, Gerald P., Colonel USMC (Ret.). Born 22 August 1932, Denver, Colorado. Married, six children. Astronaut Support crew member and CapCom for both Apollo 8 and 12; instrumental in design, development and testing of LRV used on Apollo's 15, 16, 17. Considered at one time as Commander for subsequently cancelled Apollo 20 lunar landing mission; Commander Skylab 4 16 November-8 February 1974; subsequently assigned Space Shuttle development work (Payload Support–Mission phase; Crew station hardware). Carr left NASA 23 June 1977 to join as manager an engineering consulting firm, Business Developments, Bovay Engineers Inc., based in Houston, Texas.

DUKE, Jr., Charles M., Colonel USAF (Res.). Born 3 October 1935, Charlotte, North Carolina. Married, two children. Chose NASA astronaut programme instead of X-15 project; technical responsibilities in Apollo programme included the Saturn V and crew safety areas; support crew member Apollo 10; CapCom during Apollo 11 lunar landing sequence; backup LMP Apollo 13 (he was the man who exposed Ken Mattingly, CMP Apollo 13, to German Measles forcing his withdrawal from the flight crew three days before launch April 1970); LMP Apollo 16, 16-27 April 1972, tenth man to walk on the Moon; replacement LMP Apollo 17; Technical Assistant to Manager for the Space Shuttle Systems Integration early 1973-1 January 1976, when he retired from both NASA and USAF to become a distributor for Coors Beers (the Orbit Corporation) in San Antonio, Texas.

ENGLE, Joseph H., Colonel USAF. Born 26 August 1932, Abilene, Kansas. Married, two children. Selected for X-15 Programme, June 1963, making a total of 16 X-15 flights (the eighth man to fly that craft) between 10 June 1963-14 October 1965, during which time he exceeded 280,000 ft altitude, thus gaining the astronaut title, before transferring to NASA. Engle became the first man to become an astronaut who had already flown in space; Member of the crew assigned to the thermal vacuum testing of the prototype Apollo Command Module; Support Crew Apollo 10; backup LMP Apollo 14; original LMP Apollo 17, replaced by Jack Schmitt following cancellation of Apollo's 18, 19 and 20, thus lost chance of walking on the Moon; subsequently assigned to Space Shuttle development (ALT Mission phase; controls and displays–hardware; Shuttle development aircraft liaison). In the Spring of 1976 he was chosen as Commander of the second crew assigned to Space Shuttle ALT's in 1977, flying one captive/active flight (the second) on 28 June, and one free flight (the second) on 13 September 1977. In April 1978 he was named as backup Commander for the first manned orbital flight of the Space Shuttle scheduled for June 1979.

EVANS, Ronald E., Captain USN (Ret.). Born 10 November 1933, St. Francis, Kansas. Married, two children. Astronaut Support Crew for Apollo's 1, 7 and 11; backup CMP Apollo 14; CMP Apollo 17, 6-19 December 1972; backup CMP Apollo 18 (ASTP) subsequently assigned Space Shuttle Development. Retired USN 30 April 1976; retired from NASA 15 March 1977, previous to which he was responsible for Operational Aspects, Space Shuttle Orbital Flight Tests (Ascent Phase) beginning in June 1979. Currently Executive Vice President of Western America Energy Corporation and Director of Marketing, WES-PAC, coal producing concern of WAEC.

GIVENS, Jr., Edward G., Major USAF (Deceased). Born 5 January 1930, Quanah, Texas. Married, two children. Died in an off-duty automobile accident, 6 June 1967, El Largo, near Houston, Texas.

HAISE, Jr., Fred W., Civilian. Born 14 November 1933, Bilozi, Mississippi. Married, four children. Served as support crew member for Apollo 1 follow-on flights scheduled for 1967/68, from late 1966 early 1967; backup LMP Apollo 8 and Apollo 11; LMP Apollo 13 11-17 April1970–aborted lunar landing mission, lost chance of being the sixth man to walk on the Moon; backup Commander Apollo 16. Subsequently assigned Space Shuttle work and in April 1973 he assumed additional duties as Technical Assistant to the Manager of the Space Shuttle Programme (Orbiter); in the Spring of 1976 was named Commander Crew 1 for Shuttle ALT's in 1977; flying the first (18 June) and third (26 July) manned captive flights, and the first (12 August) and third (23 September) free flights in that programme. In April 1978 he was named as one of the astronauts assigned to fly the Shuttle on one of its six orbital test flights in 1979/80; also Head of the "Dedicated Missions" group in the Astronaut Office.

IRWIN, James B., Colonel USAF (Ret.). Born 17 March 1930, Pittsburg, Pennsylvania. Married, four children.


BRAND


BULL

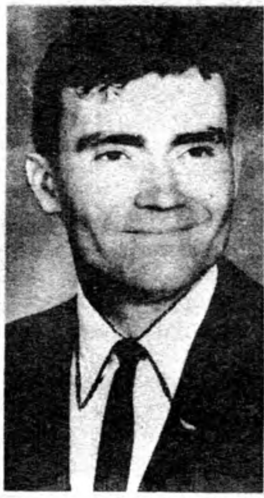

CARR


DUKE


ENGLE


EVANS


GIVENS


HAISE


IRWIN


LIND

Photos: National Aeronautics and Space Administration

Crew Cdr Thermal Vacuum Test of Lunar Module LTA-8, 1968 (tests completed on 1 June); Astronaut Support Crew, Apollo 10; backup LMP Apollo 12; LMP Apollo 15, 31 July-7 August 1971, eighth man to walk on the Moon; original backup LMP Apollo 17 13 August 1971-May 1972; retired USAF and NASA 1 August 1972 to enter religious work and form a Christian Evangelical organisation, High Flight Foundation, Colorado Springs, Colorado, of which he is currently Chairman and President. In April 1973 it was reported that he suffered a slight heart attack which was possibly the result of his strenuous work during Apollo 15.

LIND, Don L., Civilian, Dr (PhD. Physics). Born 18 May 1930, Midvale, Utah. Married, seven children. Backup Pilot Skylab 3 and Skylab 4; Pilot of Rescue Skylab which was nearly launched during the Skylab 3 mission July-September 1973; went on Sabbatical leave in 1975 until the Fall of 1976 at the University of Alaska; currently assigned to Space Shuttle Development.

LOUSMA, Jack R., Lt. Colonel USMC. Born 29 February 1936, Grand Rapids, Michigan. Married, three children; Astronaut Support Crews Apollo's 9, 10 and 13; Pilot Skylab 3, 28 July-26 September 1973; backup DMP Apollo 18 (ASTP); subsequently assigned Space Shuttle Development; April 1978, named as one of the group of astronauts assigned to fly the Space Shuttle during its orbital test programme in 1979/80.

MATTINGLY II, Thomas K., Commander USN. Born 17 March 1936, Chicago, Illinois. Married one child. Astronaut Support Crew Apollo's 8, 11 and 12; Astronaut representative in development and testing of Apollo EVAMU spacesuit and backpack; original CMP Apollo 13, replaced three days before launch due to exposure to German measles; replacement backup CMP Apollo 13; CMP Apollo 16, 16-27 April 1972; subsequently named Head of Shuttle Astronaut Office, JSC, a position he continued to serve whilst being involved in the Space Shuttle Development programme (Shuttle Office Co-ordination).

McCANDLESS II, Bruce, Commander USN. Born 8 June 1937, Boston, Massachusetts. Married, two children. Support crew Apollo 14; backup pilot Skylab 2; instrumental in the development and testing of Skylab AMU backpack; currently working on Shuttle development (EVA Mission phase and hardware).


LOUSMA


MATTINGLY


McCANDLESS


MITCHELL


POGUE


ROOSA


SWIGERT


WEITZ


WORDEN

MITCHELL, Edgar D., Captain USN (Ret.). Born 17 September 1930, Hereford, Texas. Divorced, two children, subsequently remarried. Support crew of 'early' Apollo mission; Astronaut Support Crew Apollo 9; backup LMP Apollo 10; LMP for Apollo 13,reassigned LMP Apollo 14, 31 January-9 February 1971, sixth man to walk on the Moon; backup LMP Apollo 16. Retired USN and NASA on 1 October 1972 and founded the Institute of Noetic Sciences in Palo Alto, California, of which he is Chairman; he is also President, Edgar Mitchell Corporation (EMCO), Palm Beach, Florida.

POGUE, William R., Colonel USAF (Ret.). Born 23 January 1930, Okemah, Oklahoma. Married, three children. Astronaut Support Crew Apollo's 7, 11 and 14; Pilot Skylab 4, 16 November 1973-8 February 1974. Assigned Space Shuttle development early 1975 (launch and abort mission phase; pilot's handbook); resigned NASA 1 September 1975 to become Vice President of High Flight Foundation, Colorado Springs, Colorado. He returned to NASA on 18 April 1976, as an astronaut assigned to Earth Resources Program Office. He is currently Special Assistant for Shuttle Payloads, Earth Resources Program Office, JSC.

ROOSA, Stuart A., Colonel USAF (Ret.). Born 16 August 1933, Durango, Colorado. Married, four children. Support Crew Apollo 9; Original CMP Apollo 13, reassigned CMP Apollo 14, 31 January-9 February 1971; backup CMP Apollo 16; replacement backup CMP Apollo 17 assigned Space Shuttle development (crew training). Resigned from NASA 1 February 1976 and is currently Vice-President for International Affairs, U.S. Industries Middle East Development Company, based in Athens, Greece, where he now resides.

SWIGERT, Jr., John L., Civilian. Born 30 August 1931, Denver, Colorado. Single. Astronaut Support Crew Apollo's 1, 7, 8 and 11; Backup CMP Apollo 13, replaced Mattingly and flew as replacement CMP Apollo 13 11-17 April 1970, aborted lunar landing mission; took leave of absence in April 1973 to become Executive Director of the Committee on Science and Technology, US House of Representatives; he is currently available for Shuttle flights.

WEITZ, Paul J., Captain USN. Born 25 July 1932, Erie, Pennsylvania. Married, two children. Support crew Apollo 12; Pilot Skylab 2 25 May-22 June 1973; currently assigned Space Shuttle Development (Crew station hardware; Earth resources studies), recently conducted tests under-

[Continued on page 43

TIROS-N WEATHER SATELLITES

Introduction

The first in a series of eight new operational meteorological satellites - the TIROS-N series - was launched from the Western Test Range near Lompoc, California, on 13 October The new satellites are designed to replace the current NOAA series spacecraft and incorporate major technological advances.

The potential benefits of their operation in polar orbit are:

- *Improved weather analysis resulting in more accurate weather forecasts.*
- *More specific location of ocean currents and areas of upwelling, important to fishing and shipping interests.*
- *More precise snowcover, snowmelt, and rainfall data, essential to water resource management and flood forecasting.*

It should also be possible to give more accurate alerts of high energy solar radiation levels in the atmosphere, of concern to space missions, high altitude commercial aircraft flights, long-range communications, and electrical power distribution networks.

The TIROS-N series is operated by the National Oceanic and Atmospheric Administation's (NOAA), National Environmental Satellite Services (NESS).

For the first time ever, because of its advanced data collection and platform location system, the TIROS-N series spacecraft will provide an *operational* capability to collect and transmit environmental data from platforms on land, at sea, and airborne, and also determine the geographic locations of those platforms when they are in motion on the sea or land surface or aloft.

The sensors are multi-national in character. Each spacecraft will carry a stratospheric sounding unit from Great Britain and a data collection and platform location system from France, while the other sensors were developed in the United States.

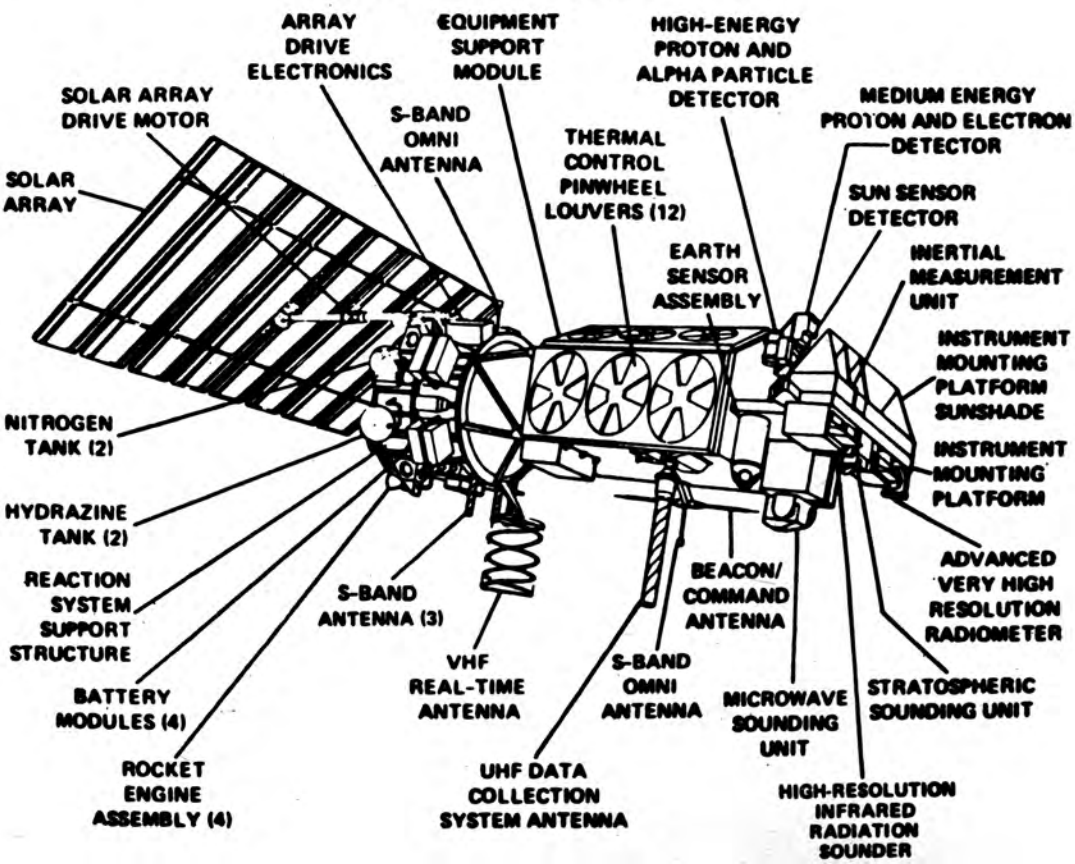
It is the TIROS-N series sensors - and the systems on the ground that communicate, process, and deliver the final products to the ultimate users - that are of greatest significance. The scanning radiometer on board, for example, is the most versatile yet to be carried aboard an environmental satellite. It is designated to gather, and store for later playback, visible and infrared measurements and images in four channels.

This will permit more precise evaluation of land, ice, surface water, cloud conditions, and sea surface temperatures, while also transmitting in real time to both Automatic Picture Transmission (APT) and High Resolution Picture Transmission (HRPT) users located in more than 100 countries around the world.

Similarly, the vertical sounder subsystem, consisting of three instruments, should give improved temperatures to within 1 degree C and moisture data from the surface of the Earth up through the stratosphere. Even in the presence of obscuring cloud cover, some data are recovered since one of the three instruments can detect microwave radiation unaffected by most clouds.

The ground support systems are multi-national also. The United States handles acquisition and processing of most

TIROS-N Spacecraft



of the data through NOAA Command and Data Acquisition (CDA) stations near Fairbanks, Alaska, and Wallops Island, Virginia, and a central processing system at Suitland, Maryland. But the Centre National d'Etudes Spatiales (CNES) of France is responsible for the processing and distribution associated with the data collection and platform location system.

The French meteorological service operates a special readout station in Lannion, France, to gather atmospheric temperature data from the satellite during orbits not visible in the United States.

The TIROS-N system will be a primary source of data for the First Global Atmospheric Research Program, Global Experiment, an international cooperative project involving some 140 countries, which began on 1 December 1978. Its instrumentation payload is designed to meet FGGE requirements for quantitative data of the Earth's atmosphere and sea surface essential to the solution of atmosphere numerical models for improved long-range weather forecasts.

History

The TIROS-N operational system benefits from experience in designing NASA's original TIROS (Television Infrared Observation Satellite) series of 10 research satellites which began with TIROS-1 in 1960.

This series of spacecraft went through a number of evolutionary stages until NOAA was satisfied the spacecraft was ready to go operational and proceeded to fund its own series.

In 1966 its first NOAA Operational Satellite was launched, followed by eight more. The Improved TIROS Operational Satellites (ITOS), with advances in research and development, were funded and launched by NASA in 1970-71 and then five similar NOAA-funded satellites were launched from 1970 to the present.

TIROS-N draw heavily on instrument technology gained from NASA's Nimbus spacecraft programme. The TIROS-N bus is a modified U.S. Air Force Block 5D spacrcraft/bus, designed to meet mission requirements and still have a growth capability of 25 per cent in payload carrying capability.

TIROS-N was designed and funded by NASA and is managed during its checkout period (approximately two months) by the Goddard Space Flight Center, before being turned over to NOAA. Spacecraft are designed and built by RCA's Astro Electronics Division, Princeton, New Jersey.

Launch Vehicle

The launch vehicle is a standard reconditioned Atlas E/F, with the second stage a part of the spacecraft. This second stage is a TE-364-15 solid fuel motor which, upon command from an onboard system, injects TIROS-N into circular orbit after separation from the Atlas. At separation the spacecraft weighs 734 kg (1,062 lb) including the apogee kick motor (AKM) assembly). The AKM contains 644 kg (1,464 lb) of propellant which burns to depletion, leaving the AKM attached to the spacecraft but weighing only 47.7 kg (105 lb) in orbit.

The Atlas is made by General Dynamics, San Diego, Calif., and the AKM is manufactured by Thiokol Corporation, Ogden, Utah.

TIROS-N Project Costs

The funding of the TIROS-N Project (including spacecraft, sensors, and ground support) is provided in the following table.

(Millions of Dollars)

	FY77	*FY78*	*FY79*	*TOTAL*
Spacecraft	26.9	4.0	0	30.9
Instruments	13.1	.1	0	13.2
Ground Operations	.4	.3	0	.7
IMS	1.0	.2	0	1.2
TOTALS (OSTA)	41.4	4.6	0	46.0
Atlas Launch Vehicle (OSTS)	4.6	4.3	0	8.9

BLACK HOLES AND GLOBULAR CLUSTERS

Data from an American-British-European satellite, the International Ultraviolet Explorer (IUE), suggest the possibility of a massive black hole at the centre of some groups of stars in the Galaxy called globular clusters.

Six of these clusters, three of them X-ray sources, have been the subject of close examination by a group of scientists headed by Dr. Herbert Gursky and Dr. Andrea Dupree, both of the Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.

IUE was launched by NASA into a modified synchronous orbit near the equator in January 1978, in cooperation with the European Space Agency (ESA) and the British Science Research Council (SRC), to study a wide range of celestial objects in the ultraviolet (UV), one of the most important regions of the electromagnetic spectrum.

Dr. Gursky says the onboard ultraviolet instrumentation provided surprises for him and his colleagues by being able to penetrate the background denseness of the clusters 15,000 light years away so that they could actually see to the core.

What they see there, according to Dr. Gursky, is probably radiation from a group of 10 to 20 bright blue stars that orbit the core. "These stars may well be orbiting a massive black hole the size or mass of one thousand solar systems."

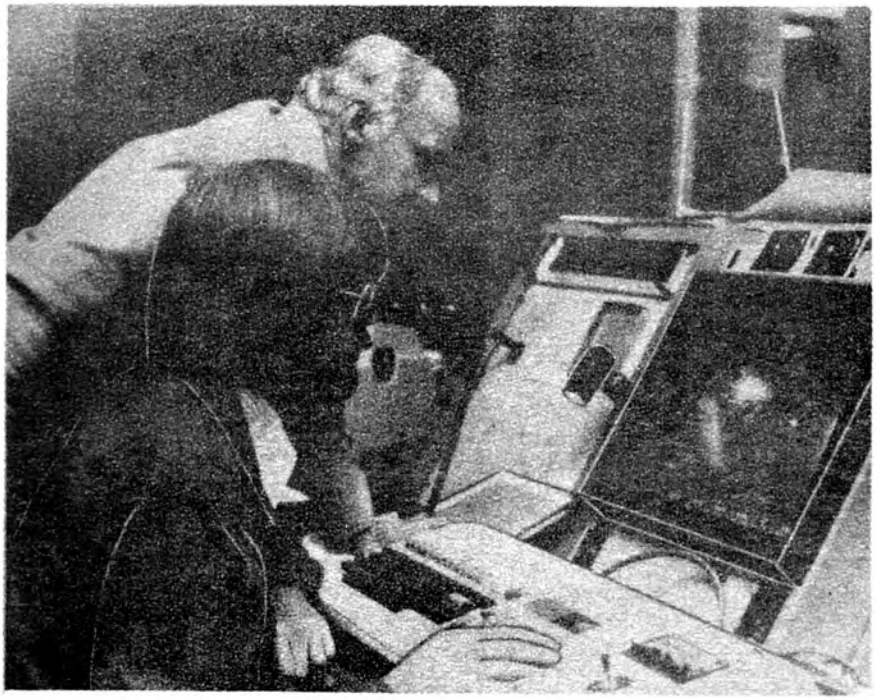
However, Gursky emphasizes that the existence of a black hole is by no means certain; the dynamics of the stars must be studied first to see how they rotate in relation to the centre of the million-star cluster. This may give a better indication of what it is that provides the necessary gravitational pull that holds them in orbit.

If the stars are indeed orbiting a massive black hole, Dr. Gursky believes they are right on the edge of it. If not, they may be providing their own gravitational equilibrium.

What surprised the observation team, says Dr. Gursky, was the fact that the short-wavelength instrumentation could so clearly cut through the million-star cluster.

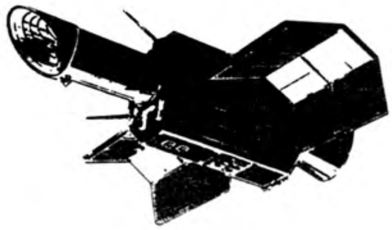
He said: "For the first time we are seeing in a clean way the centre or core of those globular clusters and we were surprised. You can see the clusters in visible light, there are lots of red giant stars there, which mask what is going on in the centre. Now we have a tool, IUE's shortwave Ultraviolet, capable of going for the first time right to the core through the whole cluster."

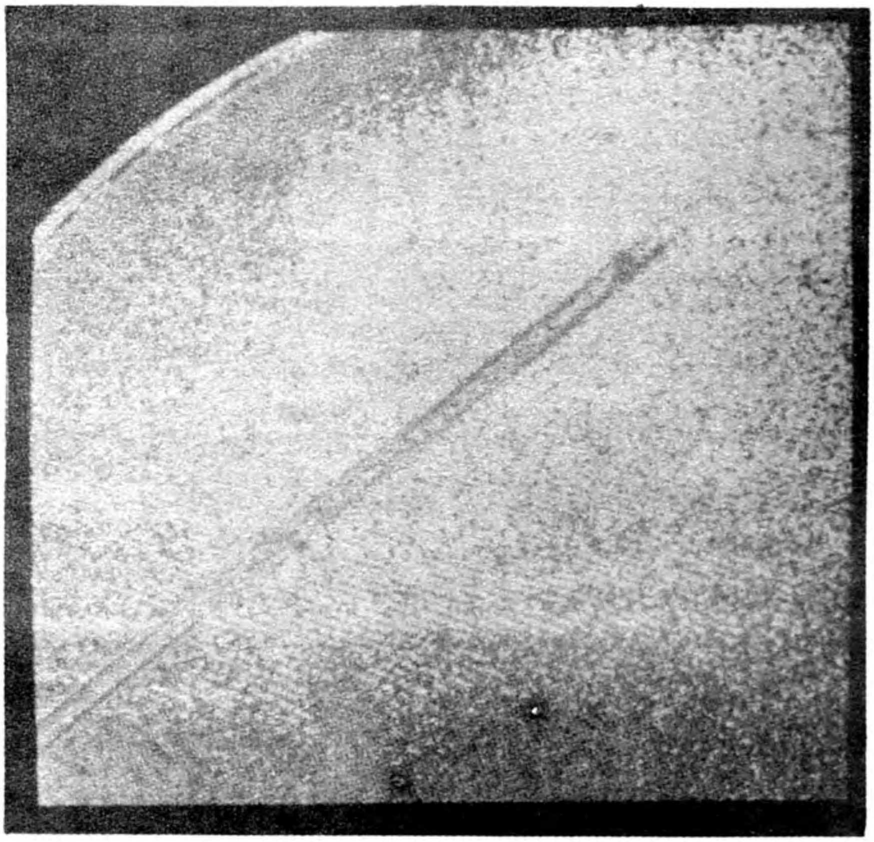
Dr. Gursky says they will continue to observe the six



Left, image of the first stellar object observed by the International Ultraviolet Explorer (IUE) appears on the viewing screen at NASA's Goddard Space Flight Center watched by Jerry Longanecker, IUE project manager (standing) and Fred Espaneak, telescope operator. Screen displays the star field mapped by IUE's Fine Error Sensor; the selected target is then observed by a vidicon camera to obtain the UV spectra.

National Aeronautics and Space Administration





Right, data obtained by NASA with the International Ultraviolet Explorer suggest the possibility that there is a massive black hole at the centre of at least some members of a fairly common type of star cluster in our Galaxy. The photograph shows two lines, each of which is the short wavelength ultraviolet spectrum of different sources located in the Globular Cluster NGC 6752. The end of each line within the faint square marker has a spot which represents UV light from the hydrogen around the Earth. The lines indicate that something very hot and bright is located at the centre of the cluster. Because globular clusters are the oldest star systems in the Galaxy – 10,000 million to 15,000 million years – there should be no hot, bright objects present.

National Aeronautics and Space Administration

globular clusters, which he likens to miniature galaxies. However, he feels they won't get a definite answer until NASA's Space Telescope is placed in orbit from the Space Shuttle in 1983. This telescope will be able to use much more powerful instrumentation, including the short wavelength of the ultraviolet spectrum, to study the blue stars in more detail.

Whether massive black holes are indeed at the centre of the clusters is an open question, but astronomers generally agree that the concept of black holes helps them explain puzzling phenomena in the Universe that cannot be explained in any other way.

For example, how else could one explain the dynamics of the strong X-ray source, Cygnus X-1, a binary star system composed of a visible and invisible companion star? The X-rays are generally interpreted as coming from the system as the result of a companion star, a black hole that is compressing material from the visible star's atmosphere prior to its complete disappearance into the black hole. The Cygnus X-1 black hole was estimated to be 10 times the mass of our Sun, but less than one millionth of its diameter.

Recently, another team composed of Princeton University and University College London astronomers announced they had used NASA's Copernicus satellite to find what appears to be a black hole in the constellation Scorpia.

THE COSMONAUTS - 14

By Gordon R. Hooper

[Continued from January 1978 issue, page 30.

Introduction

The thirteen previous instalments of this series have concentrated on the biographical data available on the Soviet cosmonauts corps. Now, with the realization of the plan to fly non-Soviet cosmonauts from member countries of the Intercosmos programme on board Soyuz and Salyut spacecraft, this series is being expanded to include this new group.

In the period 1978-83, it is planned to send cosmonauts from Bulgaria, Cuba, Czechoslovakia, the GDR, Hungary, Mongolia, Poland and Romania into space. The first of these flights took place in March 1978, when a Czechoslovakian cosmonaut was launched.

Captain Vladimir Remek

Vladimir Remek was born on 26 September 1948, in Ceské-Budejovice, South Bohemia, Czechoslovakia. He attended elementary schools in Ceské-Budejovice and Brno, and then went on to a secondary school at Cáslav in 1961, where he specialised in maths and physics. While at the school, he became involved in the youth movement, and took up aircraft-modelling as a hobby. He was also keen on reading and sports, and excelled at running.

In 1966, upon graduation from Cáslav school, he turned down the prospect of a career in nuclear physics to join the Air Force – his burning ambition. He enrolled at the Air Force College at Kosice, East Slovakia, where he received training in flying supersonic fighters and became a career officer.

During his second year at the AF College, he was accepted as a member of the Communist Party of Czechoslovakia, thanks to "good results at work, excellent study work, and firm political viewpoints." He graduated from the college in 1970 with the rank of Lieutenant. Following graduation, he was assigned to the Zvolenský combat unit, where, in a very short time, he advanced to the grade of Pilot second class. As the best pilot in his squadron, he was offered a scholarship at the Yuri Gagarin Military Aviation Academy in the Soviet Union in 1972.

In 1975, he was awarded the Medal for Service to the Motherland, and in 1976 he graduated from the Gagarin Military Academy. He returned to his unit in Czechoslovakia as a First-Lieutenant, and was soon promoted to Captain.

He returned to Czechoslovakia very shortly after the Intercosmos agreement had been announced, and he was one of the dozens of pilots picked as candidates for the programme, in July 1976. After months of medical examinations and tests, the pilots were short-listed, and Vladimir Remek was one of the two men finally selected.

The men started training at the Yuri Gagarin Cosmonaut Training Centre in December 1976. Remek found the first six months training the most difficult, but soon settled in, and was made welcome by the Soviet cosmonauts. During his training period, he would often sleep with his bed propped up by a pile of books, to keep his head lower than his feet, to help prepare him for the increased blood flow to the head experienced in weightlessness. He began training for a specific Salyut mission together with Alexei Gubarev in August 1977.

During his first training session in a Soyuz simulator, Remek lost 2 kg (4.4 lb) in weight, during a three hour session wearing a spacesuit. At the end of February 1978, Remek and the other Czech cosmonaut, together with the Polish and GDR cosmonauts, sat their final exams and tests at the Gagarin Training Centre. The results were extremely close, but eventually, Remek was selected to be the first representative of the Intercosmos countries to fly in space.

Only one month later, on 2 March 1978, he was launched into space on board Soyuz 28, flying as "cosmonaut-resarcher" to Alexei Gubarev, the commander. The Soyuz docked with the Salyut 6 spacelab, and the two men joined cosmonauts Yuri Romanenko and Georgi Grechko on board. They then spent nearly seven days carrying out a series of joint Soviet-Czech experiments, before returning to Earth on 10 March, after a flight lasting 7 days, 20 hours and 16 minutes.

Following the space flight, Vladimir Remek was awarded the titles of Hero of the Soviet Union, Hero of the Czechoslovak Socialist Republic and "Cosmonaut-flier of the Czechoslovak Socialist Republic."

Remek is a bachelor, and his father Josef Remek is a retired Lt. General in the Czech Air Force, now believed to be a deputy Defence Minister in the Czech government. Remek's mother is Mrs. Blanka Remekova.

Oldrich Pelcak

Oldrich Pelcak (or alternatively, Oldrzich Pelczak) is the other Czech cosmonaut. He underwent the same selection and training procedures as Remek, but no biographical details have been released. Pelcak acted as back-up to Remek, and is believed to have worked at Soviet MCC during the Soyuz 28 mission, possibly as a CapCom.

[To be continued

Captain Vladimir Remek.

Novosti Press Agency

SPACE EXHIBITS IN THE U.S. AIR FORCE MUSEUM

By Andrew Wilson

Introduction

Many items of importance to the history of spaceflight are not on display in major space museums but are scattered throughout other exhibition centres. The United States Air Force Museum at Dayton, Ohio, has a small but highly interesting collection of space vehicles on display among its larger collection of historic aircraft.

The history of the Museum dates back to 1923 when it was known as the Engineering Division Museum of McCook Field, Dayton. After a move to Wright Field in 1927, a museum building was erected in 1935 but facilities were taken over for other purposes during World War II. In 1948 the AF Technical Museum came into being and from 1954 began to acquire whole aircraft for public display. The year of 1956 saw the exhibition first given its official title 'A. F. Museum'. It was soon realised, however, that larger premises would be required as the collection grew and in the summer of 1971 the Museum moved to its present site, the change made possible by donations totalling some $ 6 million. President Nixon officially dedicated the new site on 3 September, 1971.

The Space Exhibits

1. *Mercury capsule*

The Mercury spacecraft in the museum is not one of the six man-carriers from the programme but is one of the later production capsules which never flew. Shipped to the Cape on 18 April, 1963 and flight-rated, it was used to provide parts in support of Gordon Cooper's 22 orbit Faith 7 mission. Some of the instrument panel equipment can be seen to be missing and an astronaut's couch has not been installed. The forward end of the capsule is largely empty and for display purposes the heatshield has been cut away to show the complexity of its construction (Fig. 1).

2. *Gemini spacecraft*

In close proximity to the tiny one-man Mercury capsule, the Gemini spacecraft hardly seems capable of carrying two astronauts. The positioning of the two vehicles, however, does highlight their similarities.

It was originally planned to move directly from Mercury to Apollo but with the realisation that intermediate flights would be required, the Mercury concept was 'stretched' by McDonnell to accommodate the Gemini programme (Fig. 2).

The basic facts of Gemini are easily recalled - 20 men were orbited in 12 flights - but one of the most forgotten areas of the programme is the USAF Manned Orbiting Laboratory (MOL) plan to orbit a military surveillance space station using a Gemini spacecraft to ferry the two-man Air Force crew back to Earth. Since EVA's were considered dangerous in those early days it was decided to employ a design whereby the crew would not be exposed to hard space in leaving their Gemini shuttle to enter the space station. With the spacecraft attached heatshield end first, the hatch was to be cut into that aft end of the vehicle. The ordinary NASA Gemini was crowded enough [1] but now the Air Force had to find adequate space to locate a hatch while maintaining heatshield integrity. From Fig. 3 it can be seen that the hatch was positioned between the two angled astronaut couches. Fig. 4 shows the hatch from an external viewpoint. The concept was flight tested by the refurbished Gemini 2 spacecraft and proved to be soundly based.

The history of the display capsule is an interesting one. McDonnell was contracted to build twelve production capsules for NASA and since twelve missions were eventually flown there were no production vehicles remaining. Where, then, did this flight-rated spacecraft come from? Spacecraft number 3 was slated for use in Project Orbit, a series of simulated flights in a vacuum chamber, but when it was reassigned to the flight programme (becoming Gemini 3) no production vehicle was available for Orbit. McDonnell had built a series of Static Articles for various test programmes and it was a vehicle from this series, Static Article number 1, which was handed over to Orbit and redesignated spacecraft 3A.

The capsule had previously been removed from the static programme after a McDonnell review in December, 1962. McDonnell fitted out spacecraft 3A with flightworthy items (except for heatshield and ejector seats) and designated it a thermal qualification test unit, a function it performed between December 1964 and February 1965, during which it ran through a total of 220 simulated orbits [2].

Following transfer to the MOL programme, the heatshield

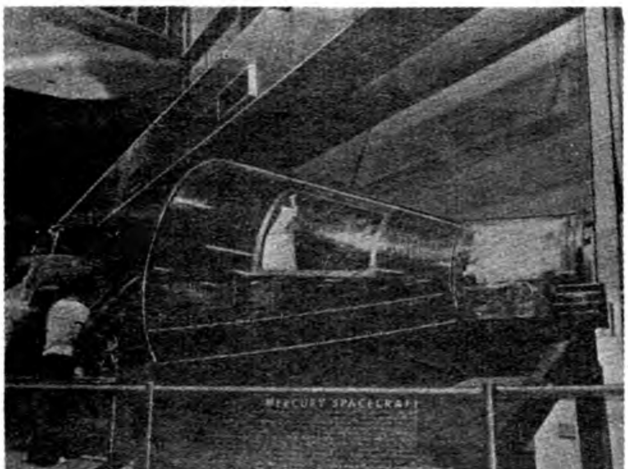


Fig. 1. An unused Mercury capsule illustrates the small size of first-generation manned spacecraft. Part of the outer skin below the hatch can be seen to be missing and the nose is imcomplete.

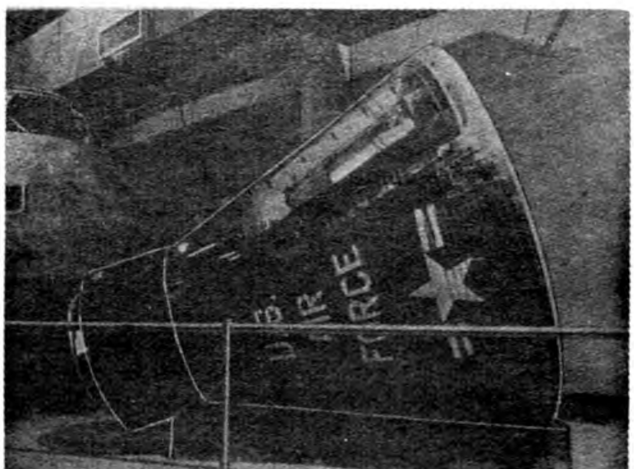


Fig. 2. Side view of Gemini spacecraft 3A complete with Air Force markings.

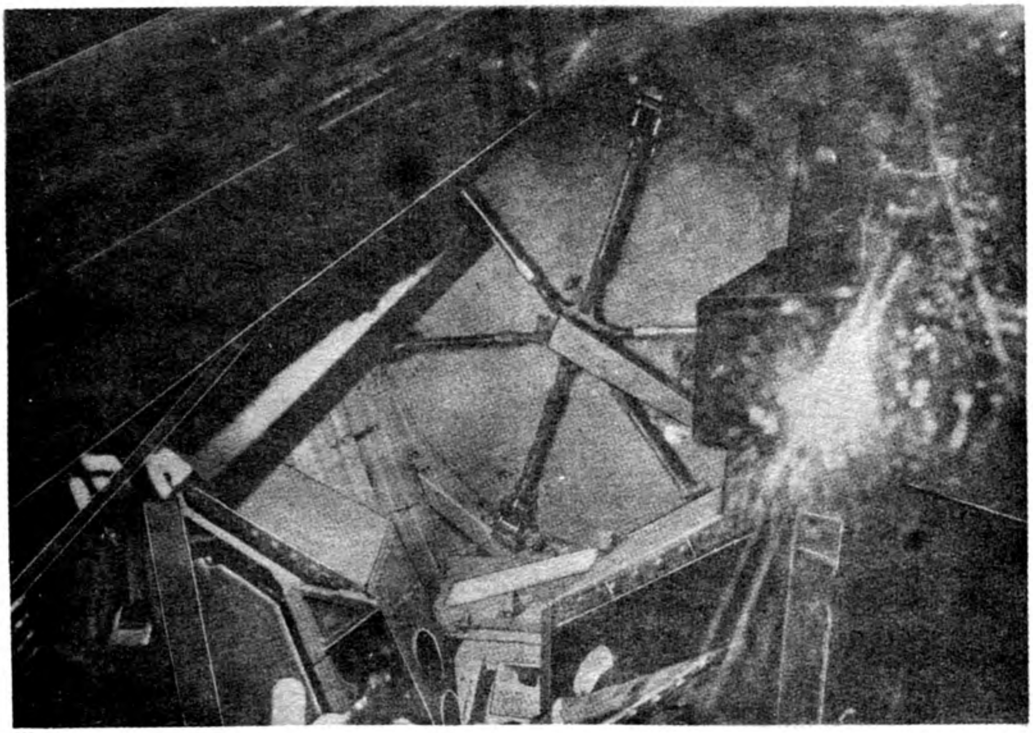


Fig. 3. The MOL experimental hatch was positioned between the two astronaut couches and held in place by six latches.

hatch was built in to the capsule but MOL was cancelled in 1969 before the spacecraft could fly. Thus the museum has a 'new' Gemini capsule on display, complete with Air Force insignia where we are used to seeing the more usual NASA decals.

3. *Apollo 15*

The Apollo 15 Command Module, number 112, in which Command Module Pilot Al Worden orbited the Moon while astronauts Scott and Irwin descended towards the lunar surface aboard Lunar Module 'Falcon', completes the manned spaceflight display (Fig. 5). On a disappointing note, visitors cannot see the command module's interior because the hatch has been left in the closed position - the Apollo 13 CM at Kennedy Space Center allows interior viewing even though all internal equipment has been torn out.

4. *X-15*

One of the fortunate byproducts of launching so many manned space shots is that there are plenty of used capsules

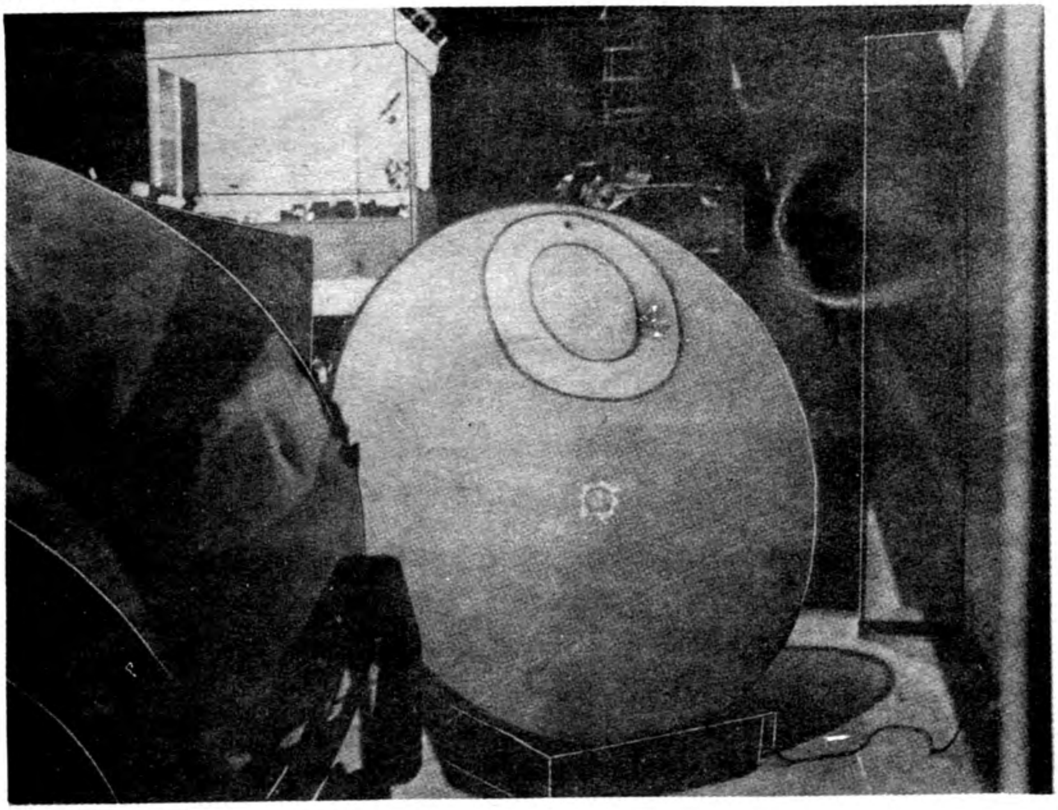


Fig. 4. External view of the MOL hatch in the Gemini heatshield. The single dark line amid the broad white band denotes the hatch edge.

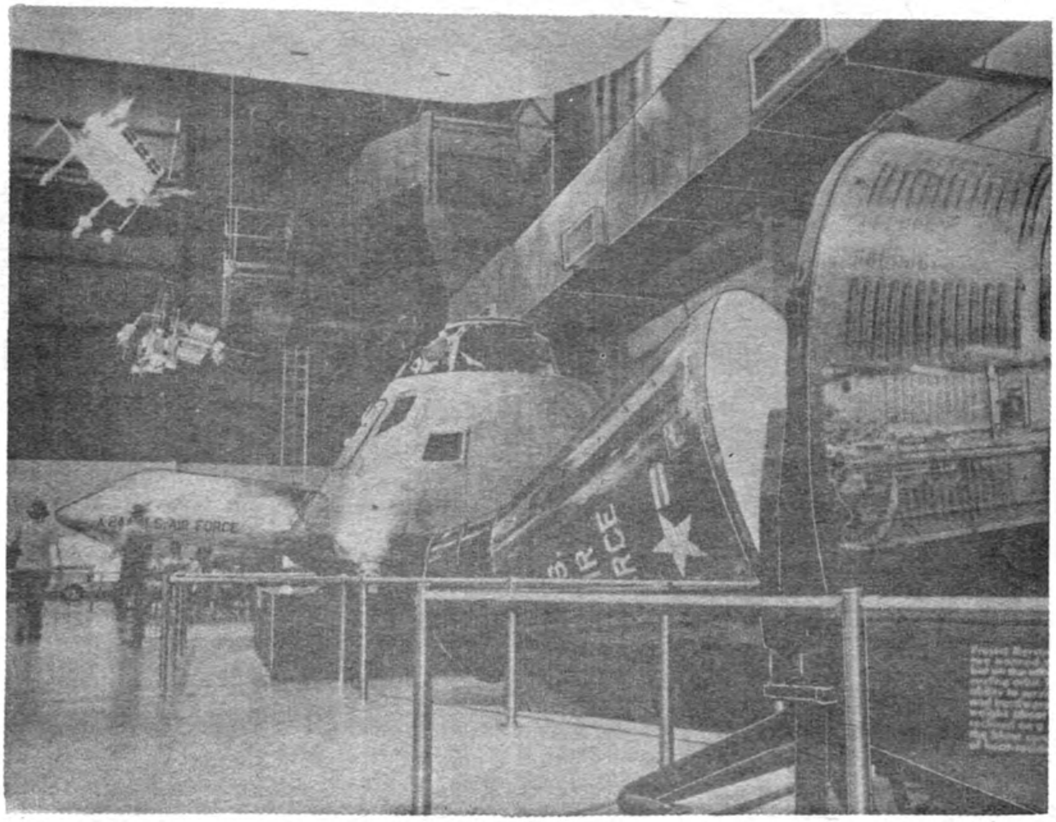


Fig. 5. General view of the space station in the Museum, with (left to right) the X-24A, Apollo 15 CM, Gemini and Mercury capsules.

to distribute to interested museums. There can be few major scientifically-inclined museums left in the US without a space display of some sort. Unfortunately for aviation museums only three X-15's were built and one of those, the third, was lost in a flying accident in 1967. The two surviving vehicles were thus assigned with care. The first is displayed in the National Air and Space Museum, Washington, D.C., the second is to be found at Dayton (Fig. 6).

The Air Force Museum probably has the more interesting of the two. Although it was not the first X-15 to be flown, it did chalk up some particularly important firsts. It was:

- the first X-15 to enter powered flight, using the XLR11 engine in September, 1959.
- the first X-15 to use the main power plant, the XLR99, in November, 1960.
- the first X-15 to attain design speed, when pilot White reached Mach 6.04 in November, 1960.

A year later, however, pilot McKay and the vehicle both suffered severe damage after a bad landing. Following release from the B-52 carrier vehicle McKay could not get the single main engine to increase beyond idling thrust and decided to make an emergency landing. After jettisoning fuel, the aircraft landed at a ground speed of 290 mph (470 kph). The stresses were too great for the port skid to take and it collapsed, throwing the vehicle over. McKay was eventually forced to retire because of his injuries and X-15 number 2 required extensive rebuilding.

Instead of returning the X-15 to its original form, the opportunity was taken to make some dramatic alterations. North American were given instructions to increase fuselage

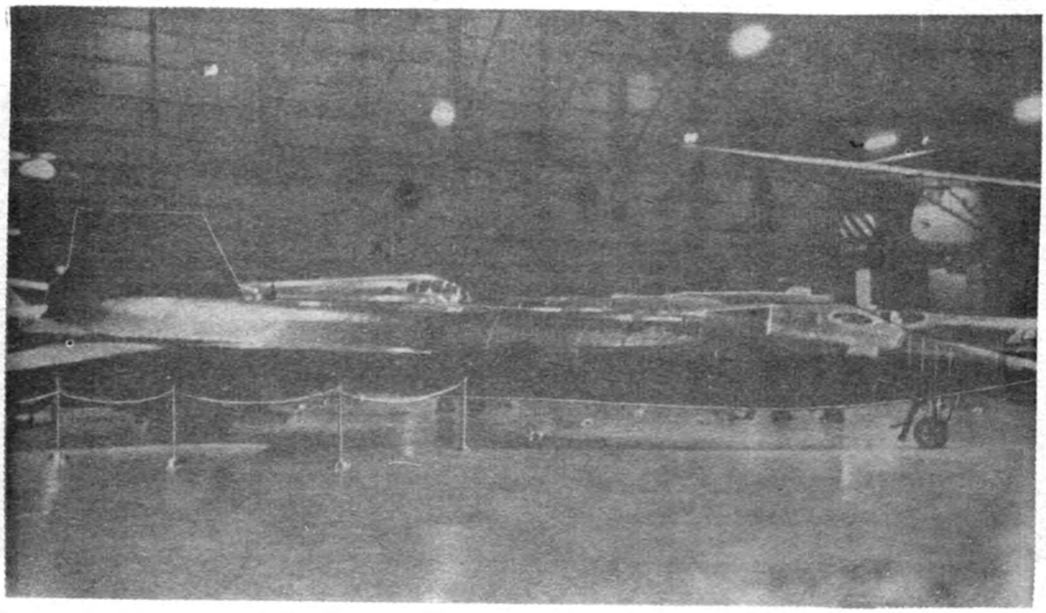


Fig. 6. The dull surface of X-15A-2 (566671) gives no indication of its appearance during high speed flight when it became heated to thousands of degrees. No trace of the experimental white ablative material remains.

length by some 29" (73.6 cm) and to add two external tanks to increase burn time from 86 seconds to 145 seconds at 100% thrust, giving the vehicle Mach 6.5 potential. Because of these extensive changes, the aircraft was redesignated X-15A-2. The fuselage lengthening is easily visible in the museum exhibit, showing as a colour difference near the forward part of the wing roots.

X-15A-2 flew for the first time in June, 1964 but had to wait until March, 1965 before using the external tanks. Even after the tanks were added speed had to be limited because with extra fuel available the design temperatures of the whole vehicle could have been exceeded.

Because of this problem, X-15A-2 was taken out of service to have its dark skin turned a gleaming white by the application of a Martin-developed ablative material which should have allowed speeds of M8 to be reached. After each flight it was planned to strip off the charred material, leaving the bare surface free for a new one to be sprayed on.

The ablator flew for the first time in August, 1967. On the second flight in October, 1967 a world speed record for winged aircraft of M6.72 (4,534 mph) was set with William Knight at the controls. The flight was marred by the loss of a dummy hypersonic ramjet under the belly and the ablator was in very bad condition, so much so that remaining flights were scrapped. X-15A-2, serial number 566671, also never flew again. After being stripped down to its natural metal it was presented to the Museum. The two remaining X-15's make interesting comparisons : 566670, in the National Air and Space Museum, is fully painted with all its decals but 566671 remains as the technicians left it after capturing the world speed record. To the visitors' advantage it stands on the museum floor, allowing close up inspection and a chance to look inside the tiny cockpit.

5. *Discoverer 14*

The displayed Discoverer capsule is significant for two reasons. Firstly, it was possibly the first payload [3] to carry cameras which returned photographs of the USSR, and secondly, it was the first object returned from orbit to be recovered in mid-air.

The Discoverer programme was designed to show that high resolution reconnaissance could be achieved by orbiting a camera system and returning the film to Earth for detailed analysis but twelve initial flights failed to prove the concept. With launch and capsule retro-fire failures the programme had stumbled badly until Discoverer 13 became the first orbital object to be recovered. The full recovery schedule, however, called for descending capsules to be caught in mid-air by trapeze-like cables trailing from the rear of a C-119 transport aircraft. The procedure proved to be difficult but not (as some suggested) impossible.

On 19 August, the capsule of Discoverer 14 (Fig. 7) was commanded down from polar orbit into its target area in the Pacific where six recovery aircraft of 6593 test squadron were waiting. The closest to the descent path began recovery manoeuvres and managed to snare the parachute-supported capsule at the third attempt, some 30 minutes after the recovery beacon was detected. So important was the capture that the 'plane's captain was awarded the Distinguished Flying Cross and his crew received Air Medals.

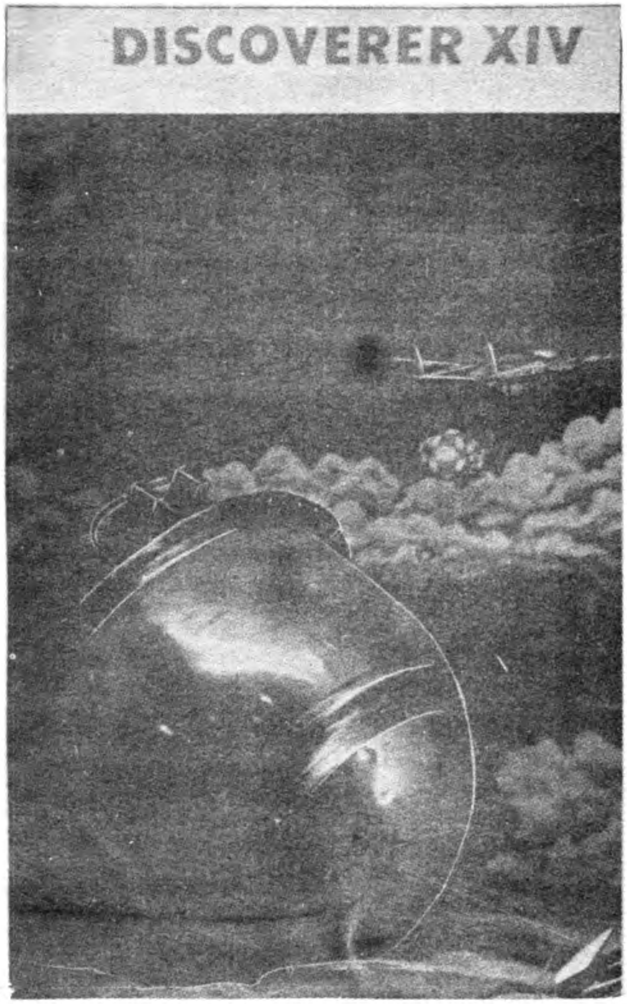


Fig. 7. The burnished metal of the Discoverer 14 recovery capsule gleams in its display cabinet at the Museum. A C-119 is shown in the background snaring a capsule and its parachute.

6. *Reusable Space Vehicle Research*

With manned military surveillance vehicles looking an attractive proposition in the early 1960's, the U.S. Air Force began to develop hardware to investigate the possibilities of reusable lifting bodies as potential ferry craft. The X-24A, a well known example of this work, is only a small part of the story. The research programme, given the blanket name of START (Spacecraft Technology and Advanced Reentry Tests), was divided into three phases : ASSET, PRIME, and PILOT.

ASSET (Aerothermodynamic/elastic Structural Systems Environments Test) was the initial phase of the investigations, flying six small gliders between 1963 and 1965, all boosted by the Thor on sub-orbital trajectories.

PRIME (Precision Recovery Including Manoeuvring Entry) was the second, more advanced, phase using vehicles resembling the X-24A on three flights, all boosted by the Atlas.

The first two phases looked at the pressing problems of re-entering the atmosphere at near orbital speed but characteristics of the final stages of reentry, including landing, had also to be investigated. This was the purpose of PILOT (Piloted Lowspeed Test), employing the X-24A lifting body.

Research was later extended by introduction of the X-24B, built around the structure of the X-24A.

All these particular studies are now completed and each one is represented in the Museum by an exhibit.

The McDonnell-built ASSET vehicle displayed is the only one of the six flown to have been recovered although others performed successfully. Following a near perfect flight, during which data on temperature, pressure and heat transfer rates were telemetered to the ground, the glider was

TABLE 1. X-24A flight log

No.	Date	Pilot	Max Alt (th.ft)	Max Speed (mph)	Max Mach No.	Flight Time (sec)	
1	17.4.69	Gentry	45.0	474	0.72	217	glide
2	8.5.69	Gentry	45.0	457	0.69	253	glide
3	21.8.69	Gentry	40.0	382	0.58	270	glide
4	9.9.69	Gentry	40.0	402	0.59	232	glide
5	24.9.69	Gentry	40.0	396	0.59	257	glide
6	22.10.69	Manke	40.0	387	0.59	238	glide
7	13.11.69	Gentry	45.0	427	0.65	270	glide
8	25.11.69	Gentry	45.0	454	0.69	266	glide
9	24.2.70	Gentry	47.0	509	0.77	258	glide
10	19.3.70	Gentry	44.4	571	0.87	424	first powered flight
11	2.4.70	Manke	58.7	571	0.87	435	
12	22.4.70	Gentry	57.7	610	0.93	408	
13	14.5.70	Manke	44.6	494	0.75	513	2-chambers
14	17.6.70	Manke	61.0	653	0.99	432	
15	28.7.70	Gentry	58.1	619	0.94	388	
16	11.8.70	Manke	63.9	651	0.99	413	
17	26.8.70	Gentry	41.5	458	0.69	479	2 chambers
18	14.10.70	Manke	67.9	784	1.19	411	first supersonic
19	27.10.70	Manke	71.4	899	1.36	417	
20	20.11.70	Gentry	67.6	905	1.37	432	
21	21.1.71	Manke	57.9	679	1.03	462	
22	4.2.71	Powell	45.0	435	0.66	235	
23	18.2.71	Manke	67.4	998	1.51	447	
24	1.3.71	Powell	56.9	661	1.00	437	
25	29.3.71	Manke	70.5	1030	1.60	446	fastest X-24A
26	12.5.71	Powell	70.9	918	1.39	423	
27	25.5.71	Manke	65.3	786	1.19	548	3 chambers
28	4.6.71	Manke	54.4	539	0.82	517	final flight

picked up from the sea on 23 July, 1964. It was transferred to the Museum in 1968.

PRIME, a larger and more advanced research vehicle, was launched by the Atlas booster on three occasions. At the trajectory's high point the whole vehicle pitched over to boost PRIME to orbital re-entry speed, from where the body's inertial guidance directed it to a preselected recovery area. Outside the denser layers of the atmosphere high pressure nitrogen jets were used for control until aircraft-type flaps became effective lower down. Four vehicles were built and three were flown but the Museum exhibit is the sole recovered example.

The final phase of the START programme began with the flight tests of the X-24A. Weighing around 5,000 lb (2,273 kg) unfuelled and with the single XLR11 engine taking the craft up to Mach 1.6, the vehicle made its first flight in April, 1969 with pilot Gentry at the controls. The series of 28 flights ended in June, 1971 after which the existing structure and systems were used as the basis of the X-24B, changing the bulbous wedge shape in to the flat-bottomed, pointed configuration which first flew in August, 1973. Tables I and II give the respective flight histories of the X-24A and X-24B.

After a programme of 36 flights ending in November 1975 the vehicle was retired and the programme came to an end. Before it arrived at the Museum a year later, the X-24B spent the summer of 1976 at Kennedy Space Centre's Bicentennial display, together with the HL-10 lifting body.

Despite the fact that the real X-24A no longer exists the Museum does have its X-24A exhibit. The original lifting body programme was a little more ambitious than its final form. To train pilots to handle the X-24A Martin began privately developing a flight trainer, the SV-5J*, the J indicating jet propulsion. Development was eventually

* *Martin's X-24A designation was SV-5P (P : PILOT); PRIME was known as SV-5D.*

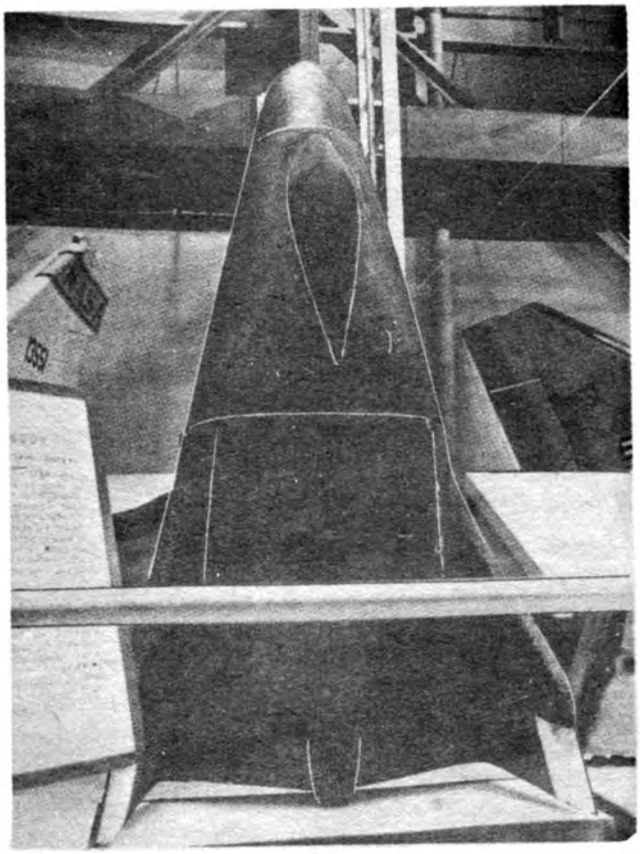


Fig. 8. Plan view of PRIME lifting body research vehicle. The similarity with the X-24A in Fig. 9 is readily seen.

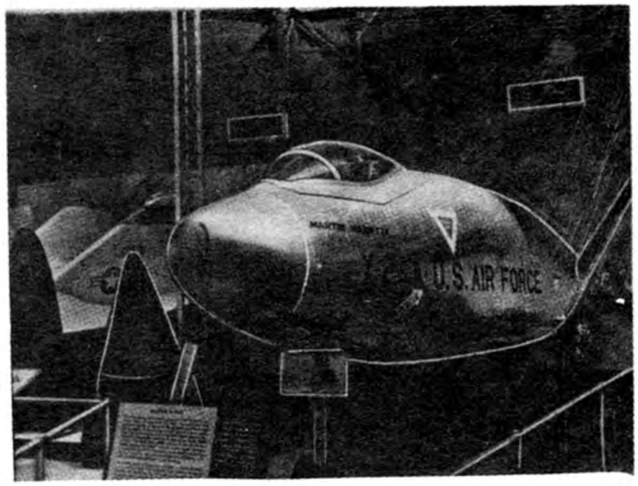


Fig. 9. The Martin-built SV-5J lifting body trainer is presented as the X-24A. The much smaller ASSET glider stands on the left with the tail surfaces of the X-24B visible behind.

abandoned and no flights were ever made but the Museum was fortunate enough to be presented with a vehicle which was almost identical to the real X-24A.

The four vehicles, ASSET, PRIME, X-24B and X-24A (SV-5J), provide an excellent insight of the START programme for the visitor and the Museum is to be congratulated on its presentation. Together with other lifting

Fig. 10. Typical flight profile of a lifting-body mission.

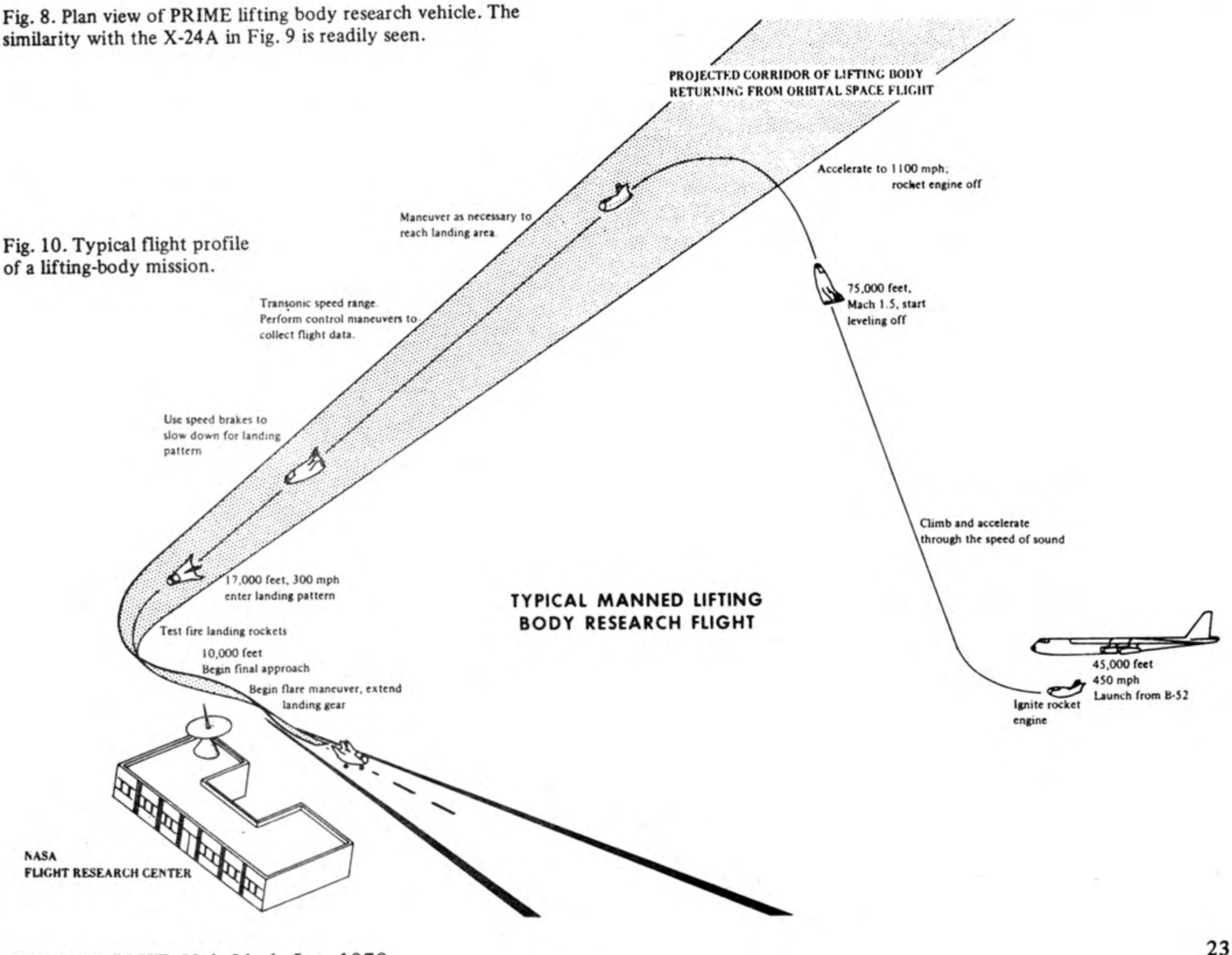


TABLE 2. X-24B flight log

No.	Date	Pilot	Max Alt (th.ft)	Max Speed (mph)	Max Mach No.	Flight Time (sec)	
1	1.8.73	Manke	40.0	460	0.65	252	glide
2	17.8.73	Manke	45.0	449	0.66	267	glide
3	31.8.73	Manke	45.0	479	0.73	277	glide
4	18.9.73	Manke	45.0	450	0.69	271	glide
5	4.10.73	Love	45.0	455	0.69	279	glide
6	15.11.73	Manke	52.8	597	0.92	404	first powered flight
7	12.12.73	Manke	62.6	645	0.99	434	
8	15.2.74	Love	45.0	450	0.68	307	
9	5.3.74	Manke	60.3	708	1.09	437	first supersonic
10	30.4.74	Love	52.0	578	0.88	419	
11	24.5.74	Manke	56.0	753	1.14	448	
12	14.6.74	Love	65.5	810	1.23	405	
13	28.6.74	Manke	68.1	920	1.39	427	
14	8.8.74	Love	73.4	1022	1.54	395	
15	29.8.74	Manke	72.4	727	1.10	467	
16	25.10.74	Love	72.1	1164	1.76	417	fastest X-24B
17	15.11.74	Manke	72.1	1070	1.62	481	
18	17.12.74	Love	68.8	1036	1.59	420	
19	14.1.75	Manke	72.8	1157	1.75	477	
20	20.3.75	Love	70.4	955	1.44	409	
21	18.4.75	Manke	57.9	795	1.20	450	
22	6.5.75	Love	73.4	958	1.44	448	
23	22.5.75	Manke	74.1	1084	1.63	461	max altitude
24	6.6.75	Love	72.1	1110	1.68	474	
25	25.6.75	Manke	58.0	887	1.34	426	
26	15.7.75	Love	69.5	1047	1.58	415	
27	5.8.75	Manke	60.0	858	1.23	420	
28	20.8.75	Love	72.0	1010	1.58	420	
29	9.9.75	Dana	71.0	990	1.50	435	
30	23.9.75	Dana	58.0	780	1.20	438	last powered flight
31	9.10.75	Ene	45.0	450	0.70	251	
32	21.10.75	Scobee	45.0	462	0.70	255	
33	3.11.75	McM	45.0	456	0.70	248	
34	12.11.75	Ene	45.0	456	0.70	241	
35	19.11.75	Scobee	45.0	460	0.70	249	
36	26.11.75	McM	45.0	460	0.70	245	

bodies and the X-15, these vehicles yielded data vital to the construction of the Shuttle, the first truly reusable spacecraft.

Conclusion

The U.S. Air Force Museum is approximately 400 mi. due west of Washington, D.C. and is well worth a visit by anyone interested in spaceflight or aviation. The museum also contains aviation exhibits as the XB-70, B-36 and a large collection of World War II aircraft.

Acknowledgements

The author wishes to thank the staff of the Museum's research library for generous help in the preparation of this article.

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29TH IAF CONGRESS - 2

By L. J. Carter

Continued from December 1978 issue, page 427]

Address by Dr. Frosch

Dr. Frosch began by reminding his audience that, although space was entering its third decade, the field was as wide open as the future of flight around 1924.

Currently, NASA efforts fall into three main categories:

(a) The use of near-Earth space for remote sensing, communications and other purposes directly beneficial to human welfare.

(b) The scientific exploration of the Solar System.

(c) Investigation of the Sun-Earth relationship, so basic to the whole bio-system in which we have evolved and live.

Remote Sensing

In the area of Earth sensing, Landsat 1, launched mid-1972 with a life expectancy of one year had now been shut down after five and a half years of operation and producing nearly a third of a million remarkably useful images of the Earth. Landsat 2, launched in early 1975, Landsat 3 launched in early 1978 and Seasat A orbited last June, have expanded the Earth sensing programmes, augmented by the Heat Capacity Mapping Satellite placed in orbit in April 1978, by three Geostationary Operational Environmental Satellites, Nimbus, Tiros, the European Space Agency's Meteosat and by a Japanese weather satellite.

Dr. Robert A. Frosch, NASA Administrator. From 1963-65 Dr. Frosch was director of nucleas test detection at the US Defense Department's Advanced Research Projects Agency (ARPA), becoming Deputy Director in 1965. From 1966-73 he was Assistant Secretary of the USN for R & D. He served as Assistant Executive Director of the UN Environment Program from 1973-75, and, immediately before becoming NASA Administrator, was Associate Director for Applied Oceanography at Woods Hole Oceanographic Institution.

International interest in Landsat in widespread and expanding as the advantages of remote sensing become more apparent. More than a 100 countries have purchased data and 11 countries are establishing ground stations to receive directly and to process and distribute Landsat data of their regions. Ground stations in Canada, Brazil, Italy and Sweden are currently receiving Landsat data of areas roughly 3,000 km in all directions from the site of their stations' antennae. A Landsat station in Iran is under construction. Australia, India, Japan, Argentina, Chile and Zaire are planning to build similar facilities. Other countries including Rumania, Mexico and Indonesia are also considering the establishment of Landsat stations.

Seasat* has been providing all-weather research data on wave heights, ice fields, icebergs, sea surface temperatures, wind speed and direction, atmospheric water content and ocean currents. It covers 95% of the world's oceans every 36 hours, supplying data equivalent to about 20,000 ship reports a day.

Most significant for the future are the powerful and complex "broadcast" satellites which permit the use of correspondingly simple, cheap and reliable ground stations, ideal for use in isolated and underdeveloped areas.

Space Probes

Six planetary probes are presently in flight:

(a) After making the first close-up observations of Jupiter, Pioneer 10 is now on its way out of our Solar System. Its sister craft, Pioneer 11, is approaching Saturn and will give us our first close look of that planet in September 1979.

(b) Two Voyager spacecraft, launched a year ago, are well on their way to make follow-up measurements of Jupiter and Saturn and their satellites. By October 1978, the first Voyager was about 705 million km from the Earth and travelling with a heliocentric velocity of 15 km per second. One-way communication time is 39 minutes 12 seconds. Voyager 2 was about 620 million km away and moving at a speed of 14 km per second.

The first Voyager is scheduled to begin Jupiter imaging in December, make its closest approach early in March 1979 and complete its Jupiter work in April. It will observe the Saturn system from August 1980-January 1981. Voyager 2 will arrive at Jupiter 4 months afterwards and reach Saturn a year behind its sister craft. Voyager 2 is currently having radio problems, with only one receiver operational and no recourse should that now fail. However, a command sequence has been stored in the back-up computer command subsystem which will permit operation of all its 11 experiments, including imaging of Saturn (but not at Jupiter) even if the remaining receiver fails. If there is no further deterioration, Voyager 2 will be targeted for Uranus after Saturn, with an expected arrival date in January 1986.

(c) The two-part Pioneer mission to Venus, consisting of an orbiter and a multiprobe spacecraft is also on

* *The Seasat, NASA's experimental ocean monitoring satellite, stopped transmitting data shortly after midnight, October 10, while the spacecraft was over Australia.*

its way, launched in May and August 1978 respectively. The first element will spring into an orbit around Venus in December, with the probes scheduled to enter the planet's hot and heavy atmosphere five days after arrival.

In addition to these six spacefarers, although one orbiter was shut down last summer, the remaining orbiter and both Viking landers are continuing to send back valuable scientific data from Mars, where they landed in the summer of 1976.

As regards the wider Universe, HEAO-1, in its first 100 days of operation, discovered 15 previously-unknown X-ray sources, including two which are half-way to the edge of the known Universe and also provided data which may, eventually, allow a positive identification to be made of at least two "black holes."

One of its most interesting results relates to the general glow of X-rays which covers the entire sky. This glow was discovered many years ago, using sounding rockets, but the more sophisticated analysers carried on HEAO-1 have made it possible to determine more precisely the *nature* of the radiation. It appears to be exactly the kind of radiation that one would expect from an extremely hot gas – about 500 million degrees. One interpretation is that this is a glow from a thin hot gas pervading the Universe. Should this be correct, then this could be the bulk of the matter of the Universe – more than all the stars, planets and galaxies combined – for, although the gas is low in density, the Universe is immense in volume.

Additionally, the International Ultraviolet Explorer – a cooperative venture with the UK and ESA, and launched January 1978, continues to provide new data on the nature of the different kinds of stars in our Galaxy and on the interstellar material from which the stars were formed, as well as many of the objects which are emitting radio waves and X-rays.

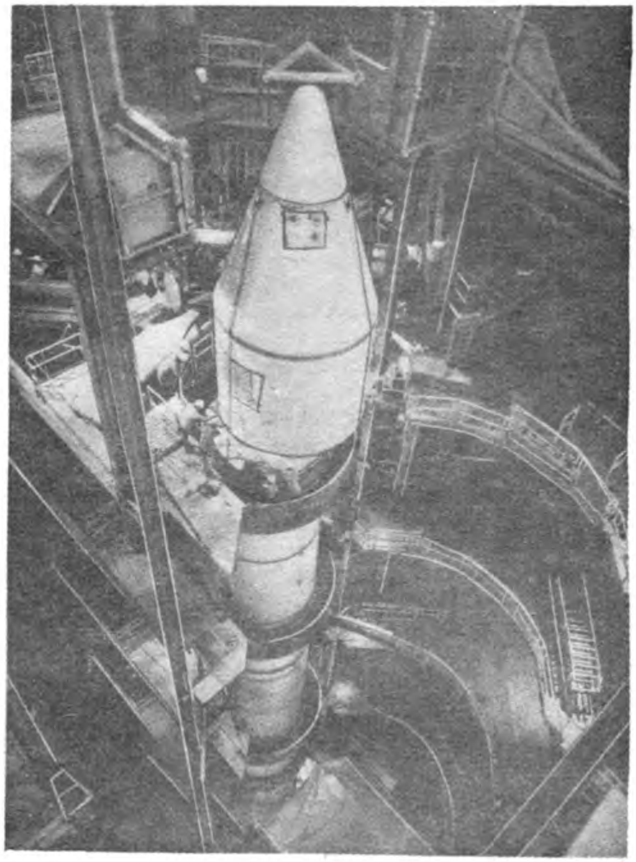
Sun-Earth Relationship

The exploration of the relationship of the Earth to the Sun, and the electrical properties of the high atmosphere of the Earth, may give us clues to help understand the world's climate and weather. While we may not be able, or not soon be able to *influence* climatic changes, perhaps we will be able, at least, to understand the reasons for them and to anticipate their effects and so prepare for them.

Space Shuttle

Unlike the US Skylab and the Soviet Salyut, designed for relatively short life-times, Spacelab – like the Space Shuttle* – is reusable, with launching and landing with the orbiter possible for as many as 50 times over a 10 year period. It can be configured either as a pressurised module, where four scientists/engineers (male or female) can work in a shirt-sleeve environment, or as an instrument carrying pallet, or as both together. Instruments on the pallet are controlled from the Mission Specialist's station on the orbiter's flight deck and are accessible by pressure suit. Crew movements between the Orbiter and Spacelab is *via* a tunnel, variable in length to ensure that the Orbiter's centre of gravity remains in the right place.

Spacelab was designed, equipped and supplied by ESA for the use of its 10 member-nations. It will fly on about 40% of all Shuttle missions during the first decade. Development of the Space Transportation System is proceeding as



The Congress programme included a film of the Shuttle 101 approach and landing tests; with the Orbiter carried aloft on top of a 747. Seven flights of this sort had taken place, with separation at 23,000 feet. The Orbiter was unfuelled. Touch down took place at a little under 200 knots. There were also shots of Orbiter 102, which will be the first one to go into orbit. Particularly interesting were the drop tests of the solid propellant booster units (One being prepared for dynamic tests with the Shuttle and external tank is shown here).

planned. Approach and landing tests were completed in October 1977 and successfully demonstrated the ability to perform the final low altitude, sub-sonic portion of the mission and land with safety and precision. Full-scale ground vibration tests are in progress and should be completed by the end of 1978. Structural tests on the orbiter, the external tank and the solid rocket boosters are also underway and on schedule.

The date of the first flight has been tentatively fixed for 28 September 1979, though the probability that this will be met is still marginal. However, there is every chance that the flight will take place before the end of 1979. The first flight will probably consist of several orbits around the Earth.

The six-flight orbital test programme will be completed early in 1980 and shortly thereafter operational missions will begin.

A major space project, made practical for the first time by the Space Shuttle, is the Space Telescope. This device, first mooted in the early sixties, will become a reality thanks to the ability of the Shuttle to re-visit for orbital maintenance.

The 2.4 metre diameter Space Telescope will be capable of containing five different instruments at its focal plane. It will weigh about 9,070 kg and will orbit the Earth at an altitude of approximately 500 km. It will be operated remotely from the ground but designed to permit mainten-

* *Boris Petrov said that the Soviets had also been investigating a low-cost space transportation system, though these investigations may yet move in several directions. Soviet calculations indicate that, in present circumstances, it is cheaper to use one vehicle for a long stay in orbit rather than reusing frequently.*

ance and the change of instruments by a space-suited astronaut, and to be retrievable by the Space Shuttle for return to Earth for extensive overhaul and a subsequent relaunch.

The Space Telescope is expected to see celestial objects with a resolution of at least 10 times better than that from the ground. It will thus be able to see objects 50 times fainter and seven times further into space and hence will explore a volume of space 350 times greater than possible with the largest ground-based telescopes.

For the future, the Galileo mission to Jupiter, scheduled for launch by the Space Shuttle in late 1981 or early 1982, will aim to conduct a most detailed scientific investigation of Jupiter, its environment and moons, including the first direct measurements of that planet's atmosphere.

The mission consists of an orbiter, which will circle the planet for at least 20 months, and a probe which will plunge deeply into the atmosphere. The orbiter will carry 10 instruments and the probe six.

A significant new project will be the Solar Polar Mission, a joint project with ESA, which aims to send two spacecraft – launched from the Space Shuttle in 1983 – past Jupiter, using the gravity from that planet to attain an out-of-ecliptic trajectory, thus permitting study of the polar regions of the Sun for the first time.

Future Missions

For the future, NASA is also considering:

(a) An orbiting power module to extend the stay-time of the Shuttle in orbit, support attached payloads, etc. (see Report on "Space Power" session).

(b) A Tethered Satellite to be suspended from the payload bay of the Shuttle and trolled through the Earth's upper atmosphere as far below the Shuttle as 100 km.

(c) Orbital demonstration of a space fabrication capability.

Several ambitious ideas have been listed for the future:

(a) A large (200-500 km) orbital Power Module to support space applications such as materials processing, constructions, advanced communication systems etc.

(b) An Orbital Transfer Vehicle to support manned operations in geosynchronous orbit in the late 1980's.

(c) As regards remote sensing, to aim for a world information network to manage planetary resources in human affairs.

Technical Sessions

Generally, IAF technical sessions are organised by specialists for specialists so there is little in them for the uninitiated. This approach is reflected by the almost total absence of journalists and members of the lay public, even though these might crowd into the "Forum" sessions,film sessions and the like.

The technical sessions are, however, places where much new technology and thinking sees the light of day and are interesting, too, for providing detailed insight into the various "states of play" and a whole host of new ideas.

Events at some of the sessions – no one could attend them all – are given below.

Remote Sensing

Three crowded sessions on remote sensing took place under the general title of "Symposium on Earth Exploration from Space" but only the opening paper was heard.

This described the application of remote sensing to monitoring marine resources and coastal zones, the aim being to apply present technology to solving possible food requirements in the 21st century. It was pointed out that the coastal zones, though comprising only 10-20% of the Earth's surface area, contained 90% of living marine resources. Landsat was used as the prime example to demonstrate the technology, with specific recognition methods demonstrated over the Gulf of Mexico. Using another example, it was reported that 400 ground truth experiments had demonstrated an accuracy of 91%. Traditional methods were too long and too costly, besides being inefficient. Pictures were shown to illustrate the actual and projected areas of fish schools, though it was pointed out that marine productivity probably depended on the quantity of nutrients crossing the shoreline and reaching the nursery grounds in the coastline areas. This underlined very clearly the need for research into the land/water interface.

CETI Meeting

There were two CETI (Communication with Extraterrestrial Intelligence) meetings, though many of the papers were more concerned with SETI (*Search* for Extraterrestrial Intelligence).

A paper on "The Ohio State University SETI Program" mentioned that, for the last five years, this had been engaged on an all-sky radio survey for signals,with an array occupying a ground area of three acres. The extremely long focal length used enabled many different receivers to be used simultaneously, with fixed horns located at ground level to lessen interference.

The policy appears to have been to use the best equipment, techniques and programme available each day – looking not in a specific frequency but in a band of frequencies. It appears that the best strategy is to examine any unusual signals in real-time, and quite the wrong thing to examine later.

Future plans of this group are to construct a second receiver and they hope to continue with their project indefinitely, even if unfunded.

The paper on "The SETI Radio Observational Project" said that there was some possibility of finding a civilisation in any direction one cared to look. There is, moreover, no particularly preferred frequency. Microwaves are a favoured area, but the frequency is very broad. Three antennae are used, 26 m and 9 m dishes to survey particular areas and a constant beam width horn. Two are used simultaneously each time and processed on a real-time basis.

Essentially, it is hoped to start a high-sensitivity restricted-frequency search, restricted also to certain areas of the sky, followed by an all-sky broad-frequency programme in 1980.

Meanwhile, the problem of radio interference continued and proposals for the protection of regions of the spectrum, to be retained for SETI, would be moved shortly at the World Radio Conference.

No one disputes, nowadays, the liklihood of life elsewhere in the Universe, though as these papers showed, arguments abound on how to search for and how to identify it.

The searches centre around the use of radio telescopes of different arrays and using different wave bands, most conducted with little funding. All, additionally, exercise considerable doubt about *what* they were looking for and *how* to identify it when it appeared. All the papers indicated this to be the central crux of their problem.

Among the several papers concerned with the origin of life itself, one emphasised the radiation effects produced over the past 4,000 million years which undoubtedly played

AWARDS MADE BY THE INTERNATIONAL ACADEMY OF ASTRONAUTICS DURING THE IAF CONGRESS

Allan D. Emil Memorial - 1978

The second Allan D. Emil Memorial Award for international space co-operation was presented to Glynn S. Lunney, (NASA) and Konstantin Davydovich Bushuyev, (Institute of Space Research, Moscow) during the closing dinner of the Congress.

Glynn S. Lunney and Konstantin Davydovich Bushuyev received the award for their contribution to the technical and management supervision of the Apollo-Soyuz test project, the world's first joint international co-operative manned space effort.

The award, established in 1977 by the IAF, is funded by the family of the late Allan D. Emil and carries with it a prize of $1,000.

Guggenheim International Astronautics Award

The 1978 Daniel and Florence Guggenheim International Astronautics Award of the International Academy of Astronautics was given to Christopher C. Kraft, Jr., Director of the NASA Johnson Space Center at Houston, Texas, U.S.A. since 1972.

Dr. Kraft directed the planning and operational control of the U.S. manned space flight programs from the first suborbital Mercury flight to the current development of the Space Shuttle Program. He played an important role in determining the initial design configuration of the space shuttle system. One of his most important and most widely recognized contributions to manned space flight was the early perception of the need to establish alternate courses of action and procedures to follow in case of system failures or other contingencies during flight.

The Award, given each year to an individual who has made an outstanding contribution to space research and exploration through work carried out during the preceding five years, carries a prize of $1,000.

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a predominate part. Among the three active agents which stirred this primeval soup were listed:

(a) Radioactive elements, which were enormously greater in past geologic times.

(b) Radioactive nuclei in uranium, produced by natural chain fusion processes.

(c) Possible short-lived super-heavy elements and catastrophic stellar processes.

Space Power Systems

One of the most interesting papers presented in this session was "Evolution of Space Power Systems", a well-balanced presentation which pointed out that the steps to a space power system stemmed from the gradual progress through economic and engineering considerations.

It made the following points:

(a) NASA's effort is overwhelmingly directed to prime power generation by photovoltaic means.

(b) A "Power Module" is being studied to support an extension of the Shuttle capability. This would be a 25 kW to 50 kW unit with arrays, batteries, attitude control and housekeeping – to be put into a specific orbit by a Shuttle flight. Once there, it can:

(i) support the Shuttle and Spacelab up to 60 days.

(ii) be left in the Tended mode, i.e. leaving the payload with the P.M. for operation with the Shuttle present.

(iii) be left in the Unattended mode, the P.M. then supporting free-flying unmanned or manned payloads.

(c) Only the array of the P.M. may be used, deployed by the Shuttle manipulator arm , to extend missions to 22 days.(An example would be for a 55° inclination launch at solstice) or to allow higher-power missions to be flown.

(d) Development of the P.M. is to be initiated in 1980, for a first flight in 1983.

Supervised Experimental Model Rocketry

Of more than passing interest in this session was the paper on "Undergraduate Space Research in the Shuttle Era." It described new opportunities now available to private individuals and institutions to send experiments into orbit on NASA's "Getaway Special" (more respectfully known as the "Self-Contained Payload Program").

Captain R. F. Freitag, whose paper on the 'Evolution of Space Power Systems' provided a fascinating glimpse into NASA thinking in a major technological area.

The existence of this programme was first made known at the 27th IAF Congress at Anaheim. Briefly, it said that space would be made available for installing small self-contained scientific payloads in out-of-the-way spaces in the Shuttle Cargo Bay. Investigators would have to supply the payload, housed in containers not more than 0.14 m^3 in volume and 90 kg in weight. The price would be $10,000, with a down payment of $500.

Since then, and up to the time of writing, the paper (July 1978), no less than 245 containers had been booked, 194 in the USA and the remainder abroad, including 2 from the UK, *viz* one from British Aerospace and the other from – which seems extraordinary – the Tramway Museum Society in Derbyshire.

Other unusual groups abound. Starlog Publications is one, as is the Society of Free Space Colonizers.

Quite a number of containers have been booked by individuals. Others have clearly identifiable purposes, e.g. many are educational institutions. One novel idea was solicited by a Tokyo newspaper, which invited its 11 million readers to submit ideas for Shuttle experiments to be included in a payload to be developed by the Battelle Columbus Laboratories. The newspaper is to solicit ideas until the end of October and to present the best to Battelle for evaluation.

[To be continued

CHANGES IN URANUS ATMOSPHERE

A major discovery concerning the atmosphere of Uranus has been made by two astronomers at NASA's Jet Propulsion Laboratory in Pasadena, California. Dr. M. J. Klein of JPL's Planetary Atmospheres Research Section and Dr. J. A. Turegano, a visiting research associate at JPL from the University of Zaragosa, Spain, have found that radio emissions from deep in the Uranian atmosphere have become 30 per cent stronger in 10 years.

The scientists, who made their observations with NASA's 64-metre (210 ft) radio antenna at Goldstone, California, explain that the radio waves, which penetrate the dense clouds on Uranus, originate deep in the atmosphere where pressures are thought to be more than 10 times greater than at Earth's surface. The observations, made in the spring of 1978, confirm the two astonomers' discovery of a year earlier.

They believe their results can be explained if Uranus' atmosphere is either warming up or becoming more transparent to the passage of radio waves. It is hard to believe that the temperature so deep in a planet's atmosphere could become 30 per cent warmer in only 10 years. A similar change on Earth would raise our average air temperature above 120 deg C (248 deg F).

It is more likely, they explain, that the change is related to the planet's unique orientation. Unlike any other planet, Uranus spins on its side as it orbits the Sun.

Every 84 years (the length of one year on Uranus), the Sun shines directly on the north pole; 42 years later the northern hemisphere is dark and the south pole points sunward.

The north pole is now turning toward the Sun after 42 years' darkness. It will point directly at Earth (and the Sun) in 1987.

The radio emissions from Uranus' deep interior are probably blocked by ammonia gas in the planet's atmosphere. The two scientists suggest that ammonia might be preferentially depleted in the polar regions of the planet - either by convection currents or chemical reactions. If this were the case, then at the present time the radio telescopes would be measuring hotter temperatures, deeper in the atmosphere, than were measured 10 years ago when the planet's orientation to the Sun was different.

Theoretical studies are now going on to determine how the radio measurements may be related to global changes in the climate, weather patterns and chemistry of Uranus' atmosphere. Those studies aid in development of general theories about planetary atmospheres, which in turn are applied to specific studies of Earth's atmosphere.

Current studies of the radio temperatures of Uranus are important to understanding the origin of the Solar System because recent results suggest that Uranus, unlike Jupiter and Saturn, has more than its expected share of the elements that are heavier than helium. This conclusion suggests that a chemical imbalance occurred in the outer regions of the Solar System some 5,000 million years ago when it was forming.

INDIA'S MULTI–PURPOSE SATELLITE

India is to have a multipurpose geostationary satellite, the first of its kind, to provide domestic public telecommunication, direct TV broadcasting and meteorological services for the sub-continent. The craft, to be known as Indian National Satellite System 1 (INSAT 1), will be launched from the Space Shuttle in the first quarter of 1981.

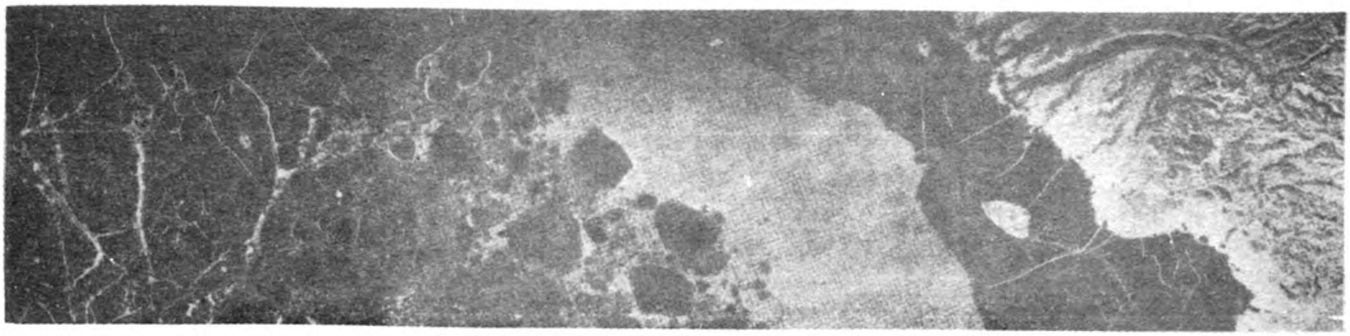
A Memorandum of Understanding (MOU) was signed between Dr. Robert A. Frosh, the NASA Administrator, and Professor S. Dhawan, Secretary, Department of Space and Chairman, Space Commission, Government of India on 18 July.

The MOU states the terms and conditions under which NASA will furnish launching and associated services to the Department of Space for the first generation of INSAT spacecraft. It is the first agreement signed by NASA with a foreign governmental agency for provision of Space Transportation (STS) launch services on a reimbursable basis.

The satellites will be built for India by Ford Aerospace and Communications Corporation.

Status of Voyager Spacecraft, 5 October 1978

	Voyager 1	Voyager 2
Spacecraft distance from Earth	704,692,000 km 437,875,000 mi	668,582,000 km 415,437,000 mi
Spacecraft distance to Jupiter	105,983,000 km 93,816,000 mi	201,354,000 km 125,117,000 mi
Spacecraft distance to Saturn	959,062,000 km 595,934,000 mi	958,804,000 km 595,772,000 mi
Spacecraft distance travelled since launch	816,533,000 km 507,370,000 mi	831,435,000 km 516,630,000 mi
Spacecraft velocity Relative to Earth	24.87 km/sec 55,632 mph	27.10 km/sec 60,620 mph
Spacecraft velocity Relative to Sun	15.43 km/sec 34,514 mph	14.18 km/sec 31,727 mph
Date of Jupiter Encounter	5 March 1979	9 July 1979



SEA VIEW SATELLITE. This night image of the Beaufort Sea Ice Pack west of Banks Island, Canada (right) covers an area about 18 by 75 miles (29 by 121 km). It was taken by the Synthetic Aperture Radar (SAR) aboard Seasat which overflew the area at 1.55 a.m. on 11 July 1978. The image contains numerous ice, water and land features. Stream channels, alluvial fans and beaches are seen on Banks Island. The dark zone adjacent to the island is an area of shore-fast ice composed primarily of first-year sea ice, three to six feet (0.9 to 1.8 m) thick. The western edge of a marginal ice zone with large and small rounded multi-year floes, typically 10 to 15 ft (3.05 and 4.57 m) thick, is clearly seen. Large floes up to 12 miles (19.3 km) in diameter are visible beyond the marginal zone.

National Aeronautics and Space Administration

Seasat image of the Baja Peninsula coast of Mexico (right), a chain of coastal islands (centre) and the Pacific (left), was obtained by the Synthetic Aperture Radar prior to dawn on 7 July. The bright ocean areas show varied patterns including groups of internal waves and several areas of wind-roughened surface. Dark patches in the lee of the mountainous islands are areas of water sheltered from the wind. North is towards the top of the 'picture.' Islands shown are Santa Margarita to the south and Santa Magdalena. Agricultural fields can be seen at upper right. Tidal channels with Almejas Bay (lower right) and Magdalena Bay (centre).

National Aeronautics and Space Administration

SPACE TELESCOPE. The huge primary mirror blank for NASA's Space Telescope undergoes inspection by technicians at Corning Glass Works, Canton, N.Y. The 2.4 m (8 ft)-diameter mirror will become a principal element of the unmanned observatory scheduled to be launched into Earth orbit aboard the Space Shuttle in 1983. The disc has since been delivered to Perkin-Elmer Corporation where the laborious process of grinding and polishing the mirror blank to its optical curvature has begun.

National Aeronautics and Space Administration

SECOND SPACELAB SCIENCE CREW

Four American scientists – a woman and three men – have been named by NASA to serve as Payload Specialists during the second Spacelab mission scheduled for 1981.

The scientists selected are:

Dr. Loren W. Acton, a research scientist at the Lockheed Palo Alto Research Laboratory.

Dr. John-David F. Bartoe, a research physicist at the U.S. Naval Research Laboratory, Washington, D.C.

Dr. Dianne K. Prinz, a research physicist at the U.S. Naval Research Laboratory, Washington, D.C.

Dr. George W. Simon of Alamagordo, chief of the solar research branch at the Air Force Geophysics Laboratory with permanent duty location at the Sacramento Peak Observatory, Sunspot, New Mexico.

Prior to the flight, two of these scientists will be selected to actually fly aboard the orbiting space laboratory and operate the scientific equipment planned for the mission. The other two will operate ground-based experiment equipment and assist the pair in orbit.

The Payload Specialists were selected by the Spacelab Investigators Working Group (IWG), which is composed of the Spacelab 2 Principal Investigators, who will have experiments aboard the mission. Each Payload Specialist is a Co-Investigator on one of the experiments to be flown.

The Spacelab 2 Payload, managed by NASA's Office of Space Sciences, consists of scientific investigations primarily in the areas of astronomy, high energy astrophysics and solar physics research. Experiments also will be performed in plasma physics, botany, medicine and space technology.

Spacelab 2 is a Spacelab "pallet only" mission with the scientific instruments exposed to space in the cargo bay of the Space Shuttle Orbiter. Because there is no habitable module included in this configuration, the scientists will operate their experiments from the Shuttle Orbiter's crew cabin.

The mission is scheduled to be launched from NASA's Kennedy Space Center, Florida, in 1981 and will orbit the Earth at an altitude of about 450 km (250 miles) for nine days.

EGYPT RESERVES "GETAWAY SPECIALS"

The Egyptian government has reserved four small self-contained payloads to be flown on the Space Shuttle in the 1980's. At a NASA Headquarters ceremony on 13 July 1978, Dr. Mohamed Shaker, Minister of the Embassy of Egypt in Washington, D.C., and Dr. Farouk El-Baz, Research Director for the Center for Earth and Planetary Studies, Smithsonian Institution, presented NASA officials with a down-payment to reserve Shuttle space.

The payloads, commonly called "getaway specials," can weigh no more than 90 kg (200 lb) and be no larger than 0.5 m^3 (5 ft^3). They are flown on the Shuttle on a space available basis for scientific research and development purposes.

The small payloads must require no additional Space Shuttle services such as electrical power or deployment in space. Each payload reservation requires a $500 down-payment.

To date, payments have been made to NASA for some 240 small payloads. Purchasers include private individuals, commercial firms and foreign countries.

The Egyptian purchase marks the first foreign educational use of the payloads programme. Egyptian students will compete in a nationwide contest by submitting proposals for an experiment to be flown aboard Space Shuttle missions. Evaluation of the proposals will be under the direction of Dr. El-Baz, who also serves as an advisor on scientific matters to Egyptian President Anwar Sadat.

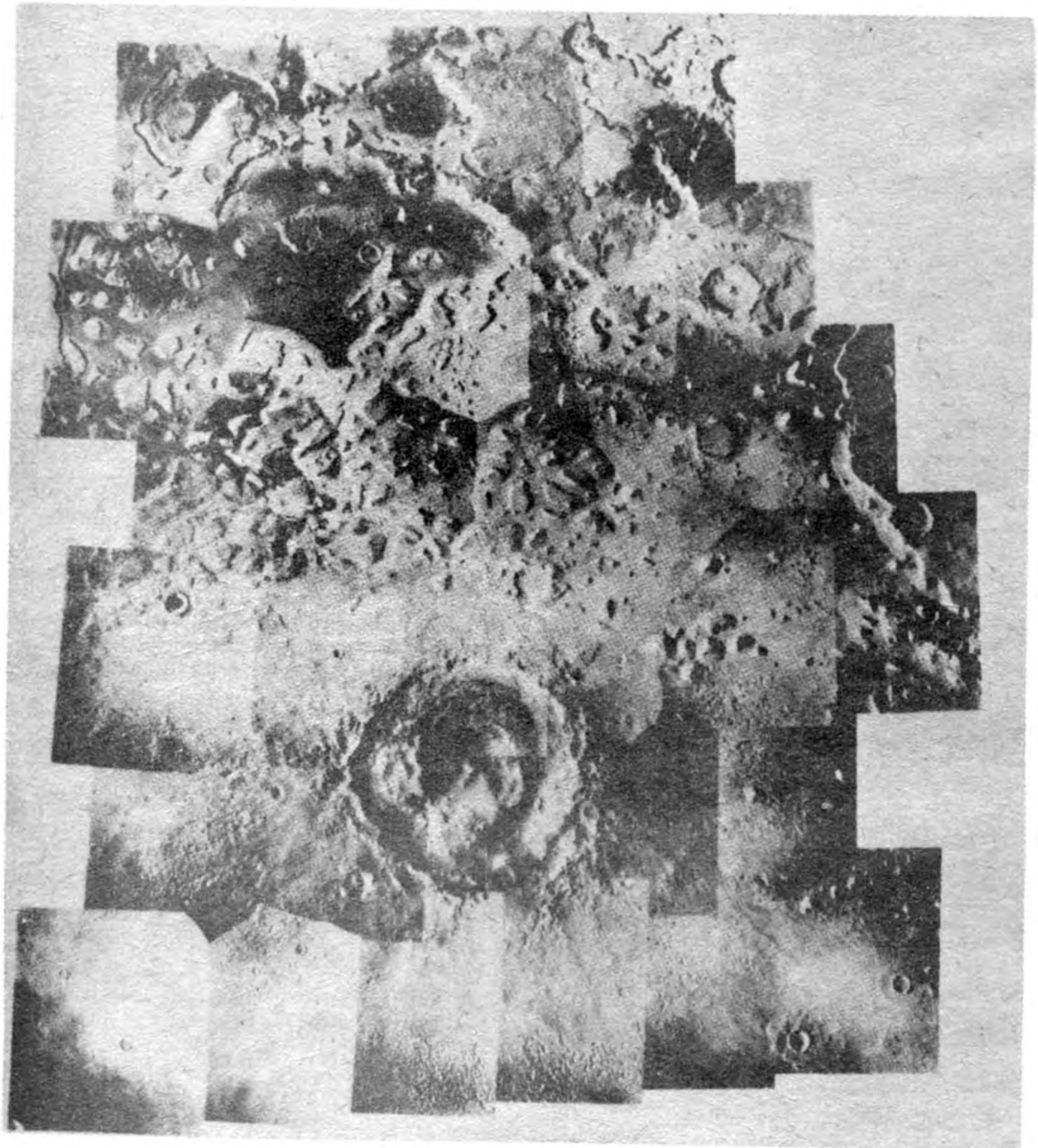
NEW SATELLITE STRUCTURE

A new type of structure designed to withstand the thermal rigors of space has been successfully tested by the Space Environment Laboratory of the Boeing Aerospace Company using a unique laser measuring device. The structure was made up of criss-cross layers of graphite epoxy material to assure practically no thermal expansion. The expansion measurement device was a special laser interferometer that used separate laser beams to permit precise simultaneous measurement of several points on the structure as it underwent vacuum chamber tests.

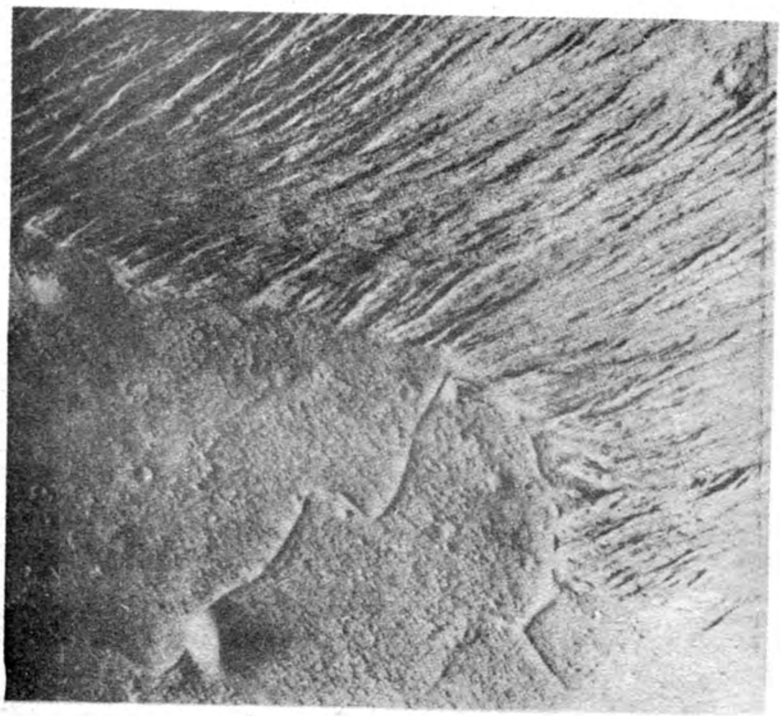
The test work was part of a contract from the U.S. Air Force's Space and Missile Systems Orgranization (SAMSO) designed to explore a satellite design that will permit a precise alignment to be maintained in orbit without the need for commands to compensate for satellite fluctuations. The main cause of such fluctuations is uneven heating which distorts the structure as the framework expands and contracts. The heating comes from the Sun's energy striking various parts of the satellite as it orbits the Earth and from the heat of internal electronic equipment.

The test conducted in one of Boeing's 14 vacuum chambers simulated the temperature, vacuum and solar energy of space. The satellite structure was rotated through the beam of an xenon-lamp solar simulator while heat was applied internally to the structure to simulate the switching on and off of electrical equipment.

Measurements of the alignment of the satellite structure were made with the laser interferometer beamed through a window in the vacuum chamber. The interferometer was developed by Boeing's Laser Physics Laboratory.

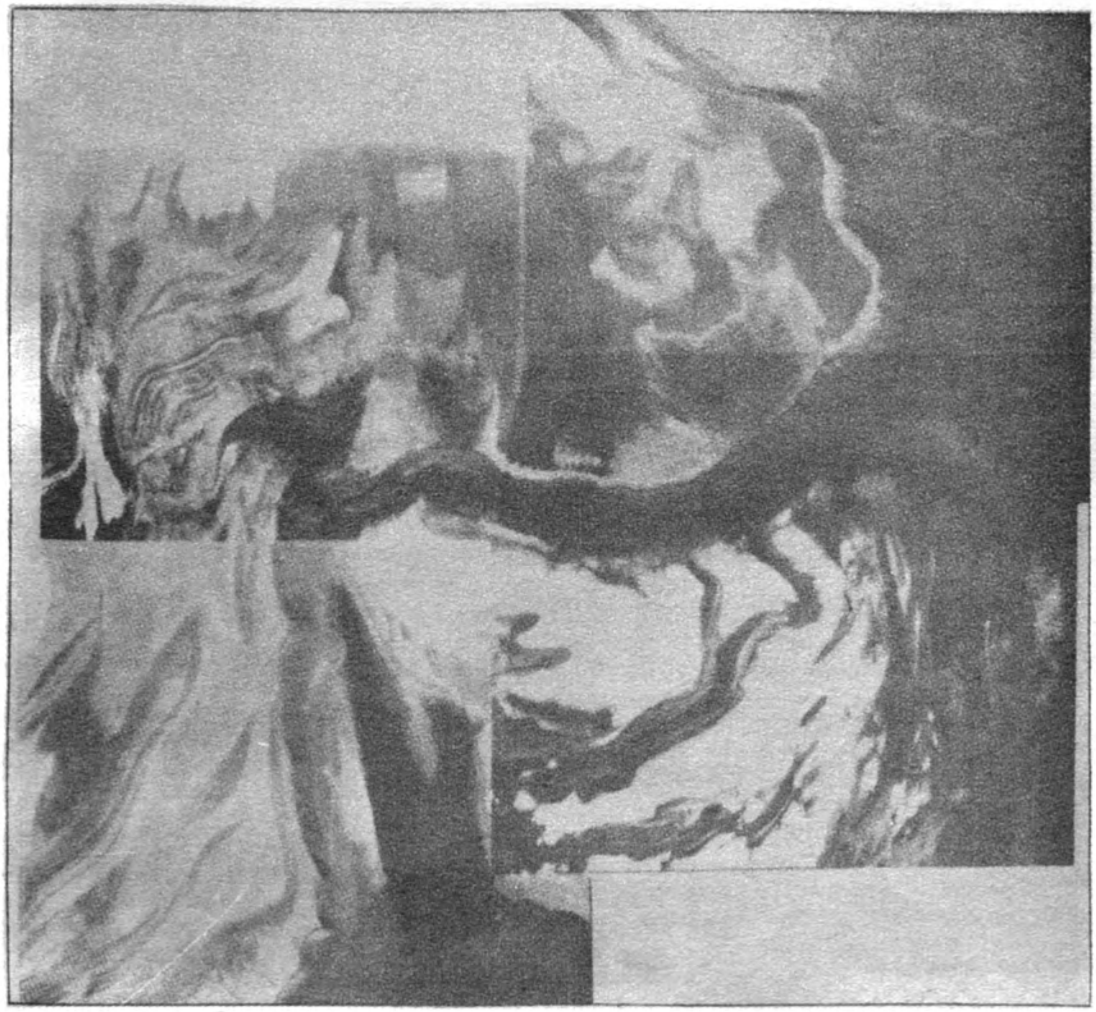


PUZZLING FEATURES OF MARS. This single frame was exposed on 11 June 1978 when Viking Orbiter 1 was at a distance of about 700 km. The surface locality approximately 20 km across is centred 6 deg south of the equator at 206 deg west longitude. This part of the planet generally exhibits fields of isolated hills with intervening plains. The hills are believed to be remnants of very ancient terrain, of which extensive areas occur approximately 200 km to the south. The isolated hill near the bottom of this frame may be one such remnant, except that there appears to be a faint indication of a crater at its summit. This might imply that it is of volcanic origin. The sinuous, narrow ridges in the vicinity of the lone hill are especially puzzling. One possible explanation is that they are volcanic intrusions or dikes but their curvilinear pattern, their great lateral continuity and their ridge-like surface forms argue against this. Possibly they are eskers – subglacial channels.



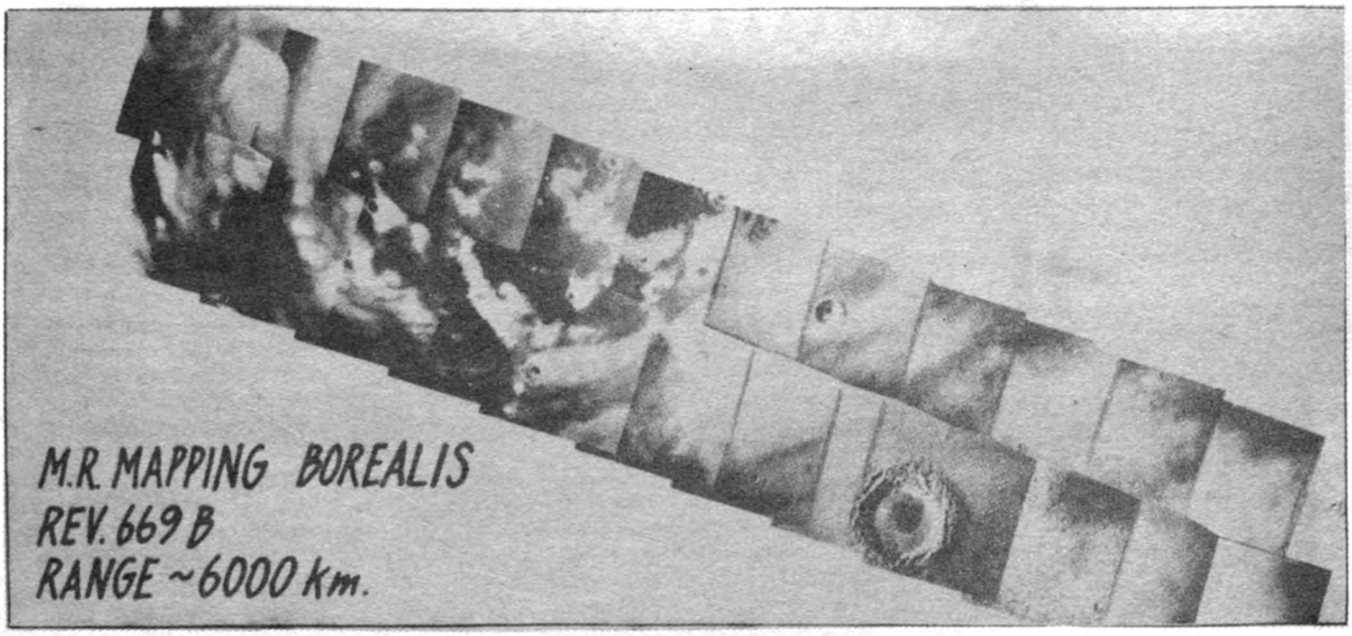
National Aeronautics and Space Administration

IMPACT CRATER. Viking Orbiter 2 obtained pictures for this mosaic which features a large impact crater, Lyot, 176 km across. The pictures were taken from a height of 7,600 km on 23 June 1978. The crater has an inner rim of impact debris and is surrounded, at least to the north, by a dense field of secondary craters. In the lower part of the mosaic are numerous mesas and isolated hills; smooth areas around the mesas are probably representative of debris material eroded from cliffs in the boundary areas. The puzzling aspect is the abundance of secondary craters north of Lyot. It is amplified by the lack of secondary craters on the plateau remnants to the south, which stratigraphically appear to be older than Lyot.



MARS NORTH POLE. This four-frame mosaic is made up of the last pictures transmitted from Mars by NASA's Viking Orbiter 2 before engineers shut it down on 24 July 1978. The region is near the edge of the north polar cap, between 79 and 84 deg north latitude. It is a plateau dissected by a canyon. The plateau is formed from many individual layers evident where corrosion has uncovered distinctive patterns of roughly parallel stripes. The season is mid-summer on Mars: strong solar heating has caused winter deposits of frozen carbon dioxide (dry ice) to sublime, leaving behind bright patches of water ice. The ice clings preferentially to flat or slightly inclined north-facing slopes, while slopes with a southern tilt are defrosted by the greater amount of sunlight they receive.

National Aeronautics and Space Administration



The *Borealis*, or north pole region of Mars, is seen in this series of mapping pictures acquired by Viking Orbiter 2 on 2 June 1978. Warmer summer temperatures have caused the winter polar cap of dry ice to sublime, thus permitting detailed surface mapping and observations of the increasingly moist atmosphere. The whitish features seen in the picture are not frost. They are a surface feature that is lighter than its surroundings. The contrast enhancement in the picture processing causes the rather small differences in reflectivity that actually exist to appear much greater.

National Aeronautics and Space Administration

'PHOTONS' OVER THE EARTH

On the 29th of July the crew of the Soyuz 29/Salyut 6 orbital space laboratory made a more than 2 hour long Extravehicular Activity (EVA) during which they inspected the exterior of the three spacecraft complex and performed experiments. The cosmonauts, Vladimir Kovalenok and Aleksandr Ivanchenkov,were the sixth and seventh Soviet cosmonauts to take a space walk following in the pioneer footsteps of Aleksei Leonov, who made a 10 minute EVA from the Voskhod 2 spacecraft back in 1965. The EVA conducted by the Soyuz 29 cosmonauts (call-sign Photon) was one of at least five planned during the operational life of the Salyut 6 space station, writes Neville Kidger.

Preparations for the EVA began many months before the launch of the Soyuz 29 cosmonauts, on June 15th 1978, in the special 'hydro-tank water-weightlessness' training facility located at the Yuri Gagarin training centre in Star City near Moscow. All of the operations that the cosmonauts were scheduled to perform outside of the Salyut complex were practiced in the tank "in the minutest detail". The training sessions were filmed on video-tape and these tapes were taken into orbit by the cosmonauts who then studied them on their on-board video monitor which is located in Salyut's main working compartment. On 27 July, two days before the cosmonauts made the EVA, they conducted a full-scale rehearsal of all operations leading up to the opening of the hatch. Whether this rehearsal included a complete depressurisation of the Salyut forward transfer compartment or was only a suit donning and doffing exercise was not immediately clarified by Soviet officials.

In preparation for the EVA the cosmonauts also adjusted the space suits, the same suits worn by Yuri Romanenko and Georgi Grechko during their 88 minute hatch opening exercise and inspection of the docking unit, located in the Salyut forward transfer compartment, on 10 December 1977. The adjustments required to the suits included tailoring them to each man's own height. In addition they checked the operation of the portable life-supporting systems and removed some of the equipment located in the transfer compartment to different parts of the station to give themselves more room in which to work.

Earlier in the flight Soviet officials had said that the Salyut crewmen would perform EVA only in the event of a malfunction, a point elaborated on by the *Pravda* correspondent accredited to the FCC at Kaliningrad. He said: "In such complicated matters as space flight, particularly in long duration missions, the unexpected, or some other mishap may occur which will impair the systems disposed on the outside of the station. On Earth various schemes have been formulated for cosmonauts to leave the station in the event of emergencies.

"It may be necessary (for example) for the cosmonauts to go into open space to remove the cover of the (BST-1M radio) telescope, if for some reason it did not open, or to examine the onboard optics or the cover of the 'location' camera. The crew may even have to examine the condition of, or even do repairs to, the solar batteries. In the course of the flight of the Salyut 6 station, as we know, this has not been necessary . . . Such operations are not included in the crew's activities (planned) beforehand. They carry out measures as required. Thus when the need arose to examine the docking system Yuri Romanenko and Georgi Grechko did this."

"The fact is that, during prolonged functioning of the orbital station, preventative inspection and repairs may be required by a number of systems located on the exterior of the station," Victor Blagov the deputy flight director told newsmen. "There are five such working itineraries, among others, envisaged in the programme . . . As we see the cosmonauts do not have to follow any of these working routines. The present operation in space is part of the programme. The purpose is to dismantle certain materials and samples sent by scientists for testing in space from the exterior of the station. We have equipped Salyut 6 with spacesuits of a new type, designed to ensure several hours of independant work in space."

Early on the morning of 29 July Kovalenok and Ivanchenkov entered the transfer compartment of the station, donned their suits and set about depressurising the compartment after sealing themselves in.*Pravda* reported that "as the cosmonauts got into their spacesuits their second sunrise (presumably of the working day) is taking place."

Before the two cosmonauts were allowed to leave the station the medical team at FCC checked their medical parameters from telemetered data. They confirmed that the pulse of both crewmen had somewhat quickened but was still within the limits of the "expected emotional upsurge". Most of the final checks came during a 30 minute radio visibility pass over the USSR. Finally, permission to proceed was given: "Photons, are you prepared?"

"All is in order."

"We give you permission to open the hatch and go out of the station."

Seconds later, at 06.57, a minute earlier than planned, the hatch swung open. At the time, according to a Washington report,the Salyut 6/Soyuz 29/Progress 2 complex was over Korea heading for the area of the Sea of Japan; it was Salyut's 4785th circuit of the Earth.

"Hatch open" came the voice from space.

Whereas Romanenko and Grechko used the docking unit hatch when making their inspection of the docking drogue unit, this time the hatch on the side of the Salyut station, especially designed for exit into open space was used.

The "reaping of the scientific harvest" began immediately after opening the hatch. Fixed to its outer surface were three panels with samples of rubber, plastics and other sealing materials used in space technology. "For the 10 months since the station was launched, these materials have been travelling in conditions of a deep vacuum, low and high temperatures and enhanced radiation," Tass reported. "The rubber is in good condition," Ivanchenkov reported. Ivanchenkov then "swam out of the hatch and immediately 'anchored' himself to the station. 'Anchor' is the name of the fixing device which reminds one of ski bindings," Tass reported. "The anchor's holding firm," Ivanchenkov said.

At this point the three spacecraft complex moved out of radio contact with the FCC and the cosmonauts were "on their own". They worked in orbital daylight for the first 30 minutes or so after they left Salyut. When the complex entered the Earth's shadow at about 07.25 (Moscow Time), over the South Pacific Ocean, the men used portable lamps to aid them in their work of dismantling the samples and experiments and other scheduled activities.

A "specialist" described the rationale behind the experiments located mainly on the hatch: "Scientists and designers building the space technology of the future are interested in everything connected with space, which is for the time being still to a large extent a mystery. And, in particular, in order to develop new materials which can work for prolonged periods in this environment, one must know how very low temperatures, solar radiation and meteoric dust, etc. affect their characteristics. These questions can be answered only by tests carried out under real space conditions. To this end micrometeorite counters and panels with specimens of various polymer and optical materials were attatched to the exterior of the station while it was still on the ground. This experiment, not requiring direct human participation, has lasted for 10 months. On its completion, it was only necessary to dismantle the equipment which had been set up and return it to Earth for further laboratory study. In this connection the exterior of the

Alexander Ivanchenkov during his space walk.
Novosti Press Agency

station has handrails and shackles almost everywhere, permitting the cosmonauts to move about to any zone they are interested in under weightless conditions, in order to make inspections of any of the units of the station which are in open space." During the EVA duties were divided exactly between the crew. Removal of apparatus to measure micrometeorites and panels with specimens of materials was done by the flight engineer, Ivanchenkov.

The crewmen fixed a TV camera near the hatch in preparation for their live telecast from open space planned to take place during the next communications pass over the USSR. That re-establishment of contact and orbital sunrise both occured at around 08.02 (MT) as the complex flew over the western Sahara desert. The TV picture showed Ivanchenkov against a background of black space and the curved limb of the blue Earth. One Soviet TV commentator was moved to say of the picture: "In these minutes it is as if one could physically feel the whole limitless of space distances." Another reporter, Petr Pelekhov of the Moscow Radio home service, said that "seven Soviet cosmonauts have now worked in open space. You can now hear the flight engineer reporting on the work done. Samples of various materials and instruments fastened there at launch - in particular a panel with which the impact of micrometeorites were recorded, a panel with samples of rubber, and a set of standard optical and heat regulation covers, and a block of cassettes with biopolymers - has been removed from the surface of the station. The flight engineer (now) holds onto a handrail which has been specially attached to the station called an anchor."

"So the 'Photons' are in open space," Kovalenok told his audience when the TV broadcast began; he continued by describing the work done and said, "we have replaced some of the equipment (removed) with new samples and inspected structures of the station and both of the spacecraft docked with it - the Soyuz 29 ferry and the Progress 2 transport cargo spacecraft. We are making the spacewalk to do work that is becoming increasingly usual in spaceflights. However, out here in space one, of course,feels very agitated . . . work in open space is difficult, but interesting."

Radio-telemetric data indicated that both the cosmonauts were in good health, and that their pulse frequency was "quite earthly". Kovalenok's pulse rate was 105 beats/min while Ivanchenkov's was 95.

The flight engineer next told his audience about his work: "The TV camera is now trained on special panels, micrometeorite sensor panels. Many of them are positioned on the exterior of the station. They give quantitive and qualitiive information about the streams of meteorites in outer space. Our task is to remove these panels and sensors and return them to specialists on Earth."

In the 54 minutes of dalyight on their second orbit the spacewalking crew also checked "features of spacecraft design intended to facilitate movement and fixation on the outside of the station. On the exterior of the station the cosmonauts installed apparatus to record the background cosmic radiation." *Pravda* also said that "already delivered were biological samples, skin of animals,and microbes; one team took them up, another returned them."

The cosmonauts worked so well in open space that they completed all of their work earlier than planned, prompting mission control to say: "If you have no more work to do, then you may go in." The commander replied: "We would just like to take our time, because it is the first time in 45 days that we have been out of doors for a walk." The complex entered the Earth's shadow for the second time during the EVA at about 08.56 (MT) and the cosmonauts climbed into the Salyut at about 09.00 (MT). Tass reported that the men had spent 2 hours and 5 minutes in space. The cosmonauts completed repressurisation of the transfer compartment, removed their suits and entered the main part of the station.

Georgi Grechko, one of the seven Soviet cosmonauts to have worked in conditions of open space, told Radio Moscow listeners that "usually when we return from orbit the scientists and engineers shower us with questions. Not infrequently, information on how it feels to be in space is limited only to verbal impressions. This time, however, specialists on materials will get from us 'live samples' which have been tested in open space. Among them are optical

and metal materials including samples of duralumin; titanium, steel, rubber, glass, paint, ceramic and other panels also block of biopolymers and radiosensitive plates to determine the total radiation received by the station. The cosmonauts have also inspected the panel of the micrometeorite recording system. No big 'wanderers' were recorded. Micrometeorites were studied from both Earth and space. Radiotelescopes can detect particles weighing 0.001 g, which could affect optical installations and solar batteries. The particles travelled at 8.72 km/h. The sensors located on Salyut 6 not only recorded collisions, but also measured the particles' penetrative force, the Soviets said.

The cassette of biopolymers retrieved comprised the MEDUSA experiment. A specialist at the FCC described this as aimed at providing new information about the origin of life. "It is the first time that such an experiment has been carried out. A special MEDUSA device containing a cartridge of cassettes with biopolymers in ampules was secured outside the station and kept for a long time in open space. The ampules were made of quartz glass, so that ultraviolet radiation could reach the biopolymers. The cassettes also contained films sensitive to radiation, to determine the total dosage. At the base of the instrument was a temperature sensor connected with a telemetric system. The main purpose of the experiment was to study the chemical properties of biopolymers subjected to the influences of open space... The exposed cassettes will be brought back to the Earth together with a control sample kept aboard the station... Analysis of the processes taking place in biopolymers under space influences will provide the information necessary for research on a molecular level. Knowledge of these changes is extremely important for the further development of space and molecular biology."

The Salyut 6 cosmonauts EVA brought the total Soviet EVA time to 9 hours 30 minutes as compared with the 103 hours 32 minutes of EVA time amassed by U.S. astronauts. In addition to that, Apollo astronauts logged 162 hours 13 minutes in lunar surface EVA time.

Following the EVA the cosmonauts, some days later, pumped more air into Salyut from the tanks on the Progress 2 transport cargo ship to compensate for the air lost during the depressurisation of the transfer section. Tass reported that the work done by the cosmonauts in open space "opens wide opportunities for using outer space for broader scientific investigations aboard future piloted orbital complexes."

KEEPING FIT IN ORBIT

Two Soviet periodicals have recently published articles detailing the programme of physical fitness training being conducted during the extended flights of two-man Soviet crews aboard the Salyut 6 orbital laboratory.

Physical training has helped cosmonauts Vladimir Kovalenok and Aleksandr Ivanchenkov to withstand hard days of work in space during their stay aboard the Salyut 6 station which began after their docking with the station on June 17th, reported *Sovietskiy Sport*. No work, even the most urgent, the paper says can be allowed to interfere with the "space physical training" exercises. The newspaper' correspondent at the Kaliningrad Flight Control centre recalled that during one of the days when the crew were unloading cumbersome oxygen regenerating units from the Progress 2 transport cargo ship, they were tempted to postpone their exercises on the bicycle Velo-Ergometer.

"We have only one container left; it won't take us long to pull it out, and that will complete the unloading of the large items. We can make up the physical training another time," Vladimir Kovalenok said, appealing to the capsule communicator at the FCC. The reply was an immediate categorical refusal from flight leader Aleksey Yeliseyev; "The labour and rest regimes must be properly observed without deviation. Throughout your flight, your physical training must take priority."

Commenting generally on the mission Dr. Igor Dmitriyevich Perstov said that problems that were associated with weightlessness were caused by the lack of the usual stresses on the bone system and changes in the pattern of blood distribution. In the course of orbital flight measures were taken to force more blood into the lower half of the body. During the period of re-adaptation to Earth conditions the opposite was done - the cosmonauts then wore tight leggings to reduce the flow of blood to their legs.

Writing in the monthly magazine *Sport in the USSR* Vladimir Konovalov said that beginning with the very first day of their flight in an orbiting station Soviet cosmonauts start preparations for the final stage of the flight, the return to Earth, in order to stand up more easily to the rigors of re-entry. The only way is to keep in condition all the time, by preventing the muscles from growing flabby and atrophying.

For 16 hours a day, their entire working day, the cosmonauts wear Penguin load-simulation suits, which partly compensate for the absence of gravity. A Penguin suit, Konovalov said, has strips of elastic which draw the spaceman's knees up towards his chest unless he counteracts their pull. Such suits have been used on all of the Soviet Salyut stations. The Penguin suit, so-called because on Earth the wearer 'waddles' along, helps the cosmonaut to put a load on the groups of muscles which enable human beings to stand erect on the Earth. In addition to the suit the cosmonauts spent between two and three hours per day doing energetic exercises. All Soviet orbiting stations are equipped with a "mini-gym" for this purpose. Chest expanders of rubber or with springs have proved to be the most rational exercising appliances because they retain their properties in weightlessness. A barbell would be useless, but a chest expander is just what the cosmonauts need. On their long flight of 96 days and 10 hours the first crew of the Salyut 6 station, Yuri Romanenko and Georgi Grechko, did their physical exercises with special zeal. They were setting up a new space endurance record, and had to maintain supreme fitness in order to retain a high working capacity. They went about their exercises with such zeal that they tore their expander.

Special physical training programmes have to be worked out before for the adaptation to weightlessness and the readaptation to gravity. A training rig known as the KFT (comprehensive physical trainer) is used for running, jumping and other exercises. Experts say (according to Konovalov) that a person has to walk at least 10,000 paces a day if he wants to feel good. The treadmill aboard Salyut 6 provides a substitute for this in the state of weightlessness. The treadmill is like an endless belt wound on two cylindrical drums, one of which has an electric drive. The cosmonaut does his exercises in a training outfit consisting of shorts and a vest. Elastic bands running from his waist to the treadmill pull him towards it, simulating gravity. The force of gravity is exerted not only on his waist and legs but also on his shoulders; in other words, there is a load on the entire skeletal frame. Rubber bands provide a load on the arms too, during walking. In addition the cosmonaut can do knee bends, chin-ups, as on a horizontal bar, or imitate weightlifting.

The space training device was tested on bedridden patients, Konovalov writes. The patients wore the Penguin suits and were suspended in a horizontal position by thin ropes; they were then brought up to a vertical treadmill. They "walked" along the wall, as it were. The patients who received this training returned to normal life after long immobilisation much easier than subjects who had remained motionless in bed.

The velo-ergometer stationary bicycle was designed at the

Likhachov Motor Works in Moscow. Besides giving the spaceman a training load it monitors his physical condition. Using the telemetry data the spaceman can regulate the physical load by adjusting the "resistance" of the pedals, e.g. to simulate the exertion of uphill riding or fast riding along a level road.

Each cosmonaut was able to choose an exercising apparatus that suited his own disposition. Georgi Grechko, a philosophically minded person, preferred the treadmill. Prior to his flight Grechko told Konovalov that he was hoping to combine his mission with an exercise programme that would help him to lose at least 5 kg of extra weight. Romanenko, who has a far more energetic turn of mind, liked his workouts on the stationary bicycle. In one of the communications sessions with the ground Grechko said: "I can recommend Yuri Romanenko for the national cycling team. He pedals away so enthusiastically that I feel he could win any race."

Few cycling champions, concluded the *Sport in the USSR* article, can boast of the kind of performance which Yuri Romanenko took as a matter of fact during the flight. He reported that during one exercise session he had "just finished cycling from the Persian Gulf to the Kamchatka Peninsula!"

Even so Yuri Romanenko had a long way to go to beat the record set by the Skylab 3 commander Alan Bean during the 59 day long flight of that crew. In one exercise session on Skylab's ergometer the astronaut pedalled away for over 93 minutes, thus becoming the first man to pedal around the world, as that was the length of time that the station took to complete one revolution.

SHUTTLE CREW WATER SURVIVAL

Sixteen astronaut candidates from NASA's Johnson Space Center in Houston, Texas, spent three days in training at the Homestead Air Force Water Survival School in Florida from 31 July-2 August. Most of the 35 astronaut candidates had previously undergone water survival training before entering the NASA programme. Included among the 16 were the six female astronaut candidates.

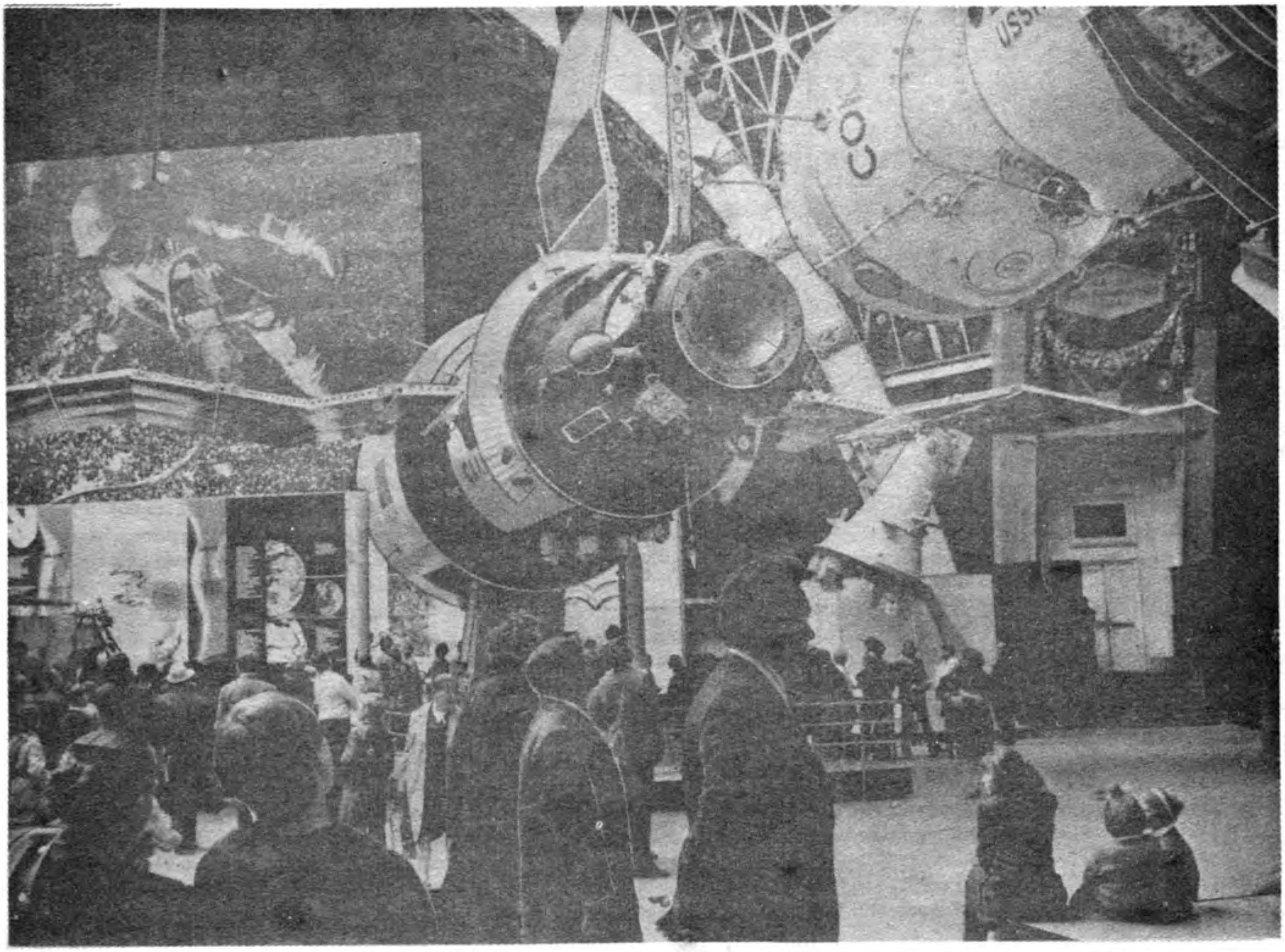
Each day's activities during the course included classroom lectures on water survival techniques in the Space Shuttle age plus actual training in the water environment. Briefings on procedures preceded each activity.

The training included jumping from a tower wearing a tethered parachute harness while sliding down a wire to a landing in the water. The candidates also were towed through the water in a parachute harness, simulating a parachute dragging one across the surface and having to release one's self.

Other exercises required astronaut candidates to be towed aloft under a parasail canopy, land in the water and be picked up by a boat. On the final plunge into the water suspended from the parasail, astronaut candidates came down with full survival gear. A helicopter picked them up from their life raft.

The Air Force Water Survival School is operated by the 3613th Combat Crew training squadron with headquarters at Fairchild Air Force Base, Washington.

Replicas of the Salyut space station and Soyuz ferry on display in the Cosmos Pavilion at Moscow's Exhibition of Soviet Economic Achievement. Salyut weighs 18.9 tonnes, has an overall length of some 15 m and an internal volume of about 90 m^3. Soyuz weighs 6.8 tonnes, has a length of 7.94 m and a diameter of 2.2 m. Its internal volume is 10.3 m^3. Soyuz data are provisional.
Panorama DDR/Zerfrabild



SHUTTLE ENGINE PROGRESS

A flight-configured developmental Space Shuttle engine has exceeded 5,000 seconds in test firing at NASA's engine test facility in Bay St. Louis, Miss. This is significant because that mark is the same as a production engine must meet in order for the Space Shuttle main propulsion system to be certified for manned flight.

Space Shuttle main engine testing, both in the number of tests and time accumulated, increased dramatically between 12 August and 20 September 1978. In that period, approximately 7,100 seconds of testing time have been accumulated on two engines, bringing the total time of engine testing to more than 25,000 seconds in 342 tests.

Of these tests, five consecutive runs of 520 seconds (the amount of time the engines must fire to place the Space Shuttle in orbit) were conducted on one engine at rated power level. Preliminary flight certification requires 5,000 seconds on a flight engine and is expected in the Spring of 1979.

Full duration testing of the complete main propulsion system, a cluster of three engines, is scheduled to resume in early 1979 when the first manned orbital flight configuration engines become available.

SPACE MEDAL OF HONOR

Six astronauts have been given the Congressional Space Medal of Honor, the first such medal ever awarded by the United States. The presentations were made – one posthumously – by President Jimmy Carter during a visit to the Kennedy Space Center on 1 October 1978. This date marked the 20th anniversary of the foundation of the National Aeronautics and Space Administration.

The award, authorised by the Congress in 1969, is conferred *"to any astronaut who in the performance of his duties has distinguished himself by exceptionally meritorious efforts and contributions to the welfare of the Nation and of mankind."*

The citations for the award are for:

• **Neil A Armstrong,** for actions to overcome problems and land his spacecraft safely on the Gemini 8 mission in March 1966 and for "steady cool professionalism, repeatedly overcoming hazards" on the Apollo 11 mission in July 1969, when he became the first person to walk on the Moon.

• **Frank Borman,** who commanded the Gemini 7 mission in December 1965 and the Apollo 8 mission in December 1968, both of which "significantly hastened and facilitated achievement of the manned lunar landing objective." On Apollo 8, he commanded the first manned spacecraft to escape the Earth's gravity.

• **Charles Conrad, Jr.,** who, from August 1965 to June 1973, participated in four space flights of increasing duration, complexity, and achievement. His contribution culminated in the first manned Skylab mission in May and June 1973, when he commanded the crew which performed "lengthy, dangerous, and strenuous activities that were necessary to repair damage inflicted on the orbital workshop during launch and thereby save the 2,000 million-dollar programme."

• **John H. Glenn, Jr.,** the first American to orbit the Earth in the third manned mission of project Mercury in February 1962, when his professional handling of extreme difficulties with the spacecraft "demonstrated the value of the human pilot in space.... He returned to a nation and a world which seized on him as a major hero. This difficult role he handled with the same polite dignity that he brought to all his assignments."

• **Virgil I. Grissom** (posthumous), the second American in space, who, from July 1961 to January 1967, participated in Mercury and Gemini space flights and lost his life during preparation for the first Apollo flight. Experience gained from the first manned Gemini flight in March 1965, which he commanded, led to "procedures necessary for the support of subsequent long-duration and rendezvous missions."

He died in a flash fire in January 1967 that swept through the Apollo spacecraft on the launch pad.

• **Alan B. Shepard, Jr.,** who was the first American in space aboard the Mercury spacecraft in May 1961, which "demonstrated that this country lacked neither the courage nor the technology to compete in the new arena of space." He was also cited for showing "the highest qualities of leadership" as commander of Apollo 14, the third lunar landing mission in February 1971.

COSMONAUT GEORGI DOBROVOLSKY

A new 9,000 ton ship, the *Cosmonaut Georgi Dobrovolsky,* has been added to the series of Cosmonaut Research ships operated by the Soviet Academy of Sciences and designed for studies of the upper atmosphere and outer space, controlling flights and to receive and transmit information from spacecraft and orbiting stations. The first in this present series, *Cosmonaut Vladislav Volkov,* was launched last year (*Spaceflight,* December 1977, p. 439), and a third nearing completion will be named *Cosmonaut Victor Patsayev* after the Research Engineer on Soyuz 11.

Georgi Timofeyich Dobrovolsky, a Lt-Colonel in the Soviet Air Force was born on 1 June 1928 in Odessa. He became a cosmonaut in 1963 and possibly served as a member of the backup crews for the trio of Soyuz flights in October 1969 (Soyuz 6, 7 and 8), before becoming backup Commander Soyuz 10, subsequently being assigned as prime Commander Soyuz 11, flown between 6-30 June 1971. It was during this mission that the first manned space station was created when for 23 days the three Soyuz 11 cosmonauts lived and worked inside the Salyut 1 scientific station. Unhappily during Soyuz 11's descent on 30 June 1971, the three cosmonauts died due to loss of cabin atmosphere caused by a faulty valve in the descent module.

OTRAG'S THREE-STAGE ROCKET

The West German company of OTRAG (Orbital-Transport-und-Raketen AG) expects to launch a three-stage rocket from the Republic of Zaire next March. The vehicle is expected to have 48 to 60 standardized kerosene/nitric acid engine modules in the first stage, 12 in the second and four in the third.

Before this major launch, OTRAG will conduct another test of the single-stage, four-engine rocket which went off course immediately after launch on 5 June 1978. Company engineers traced the fault to a malfunction of a flight trajectory control valve in one of the engine modules, causing offset thrust. Each module develops a thrust of some 3,000 kgf and each engine is selectively throttleable in response to signals from an inertial platform to control the vehicle's attitude. OTRAG say they have now fixed the valve problem.

The OTRAG project was reviewed in the article "Into Space by Low Technology?" *Spaceflight,* January 1978, pp. 2-8.

SOCIETY NEWS

A LARGER 'SPACEFLIGHT'

With this issue of *Spaceflight* we take another forward step in our Development Programme. Thanks to new arrangements we have been able to make with our printers, the magazine is now being produced by Web Offset which enables us to progress to 48 pages per issue, a regular increase of eight pages.

Some two years ago we were able to increase our page size by adopting the A4 metric standard: now, Web Offset gives us the added opportunity of allowing an increased size of pictures with only a modest increase in cost.

The larger *Spaceflight* will enable us to extend our coverage of important events in the field of international Astronautics, of which our extensive reports of the recent IAF Congress in Dubrovnik are an early example.

We are looking forward to an expansion of our news of Society affairs following the opening of our new Headquarters Building south of the Thames – the foundation of our Development Programme, made possible by the generous support of a large body of members and friends of the Society, at home and abroad.

We shall also be able to respond to readers' requests for greater coverage of Space Science and Astronomy.

We have already taken steps to include 'Astronomical Notebook' as a regular feature. This long-running review of the astronomical literature, contributed by Dr. J. S. Griffith of Lakehead University, Ontario, originally appeared in *Spaceflight* but was transferred to the Interstellar issues of *JBIS* when the volume of material on space science and technology became too great for us to accommodate in our available 40 pages.

In transferring 'Astronomical Notebook' back to this magazine, we shall be bringing to readers a more timely flow of information on the new discoveries – many of which now stem from satellites and space probes – which are revolutionising astronomical knowledge.

At the same time, more room will become available in *JBIS* to enlarge on the highly successful theme of Interstellar Studies. K.W.G.

MORE SOCIETY PUBLICITY

The Society is benefiting greatly from its activities in promoting press publicity for the Daedalus Project. A recent example was the half-page spread, with illustrations, appearing first in *The Washington Post* and subsequently syndicated widely throughout the United States.

Another was an extensive write-up in *Wissenschaft u. Technik*, prepared by Willy Lutzenkirchen.

Gerry Webb also added a sizeable boost with a talk on Daedalus on LBC – a local radio station in London reaching a 150,000 audience on 31 October 1978 and added even more boost to our efforts by donating the entire fee to our Development Appeal.

On a slightly different tack, the *Daily Telegraph* earlier in the week featured a note about the paper by Alan Bond and Tony Martin in the November 1978 issue of *JBIS* entitled "A Conservative Estimate of the Number of Habitable Planets in the Galaxy."

Not to be outdone, Mitch Sharpe reported that a note about the forthcoming issues of *JBIS* on astronautics history had appeared in *Industriearcheologie* (FGR).

Meanwhile, back at the ranch, the HQ staff continued grinding the wheels to procure more Daedalus reviews, the latest of which, at the time of writing, appeared in the *New Scientist.*

Those members who can help to spread the word even more widely by additional reviews or references in local papers, house and other journals or magazines, books etc., are cordially invited to do all they can to foster our activities.

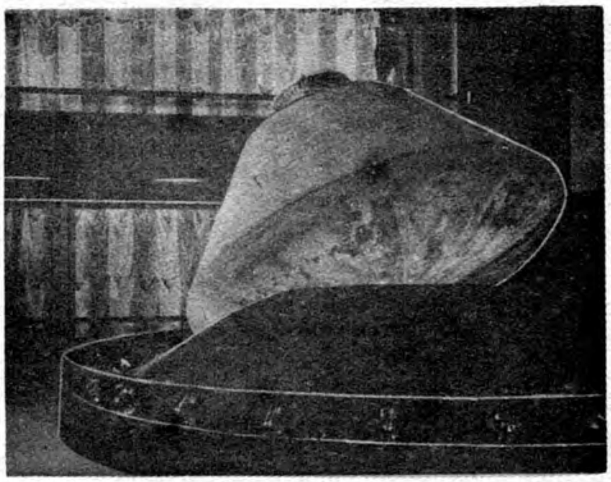
SCIENCE MUSEUM VISIT

The Science Museum at South Kensington has changed greatly from its appearance only a few years ago, as a party of BIS members discovered during their visit on 26 November 1978. Gone were the long rows of glass showcases: instead are large, dynamic, colourful displays with maximum emphasis on pleasing and interesting presentations. So much has the Science Museum been modernised of late that it now attracts over 3½ million visitors every year, thus topping the European museum attendance league apart only from the Louvre in Paris.

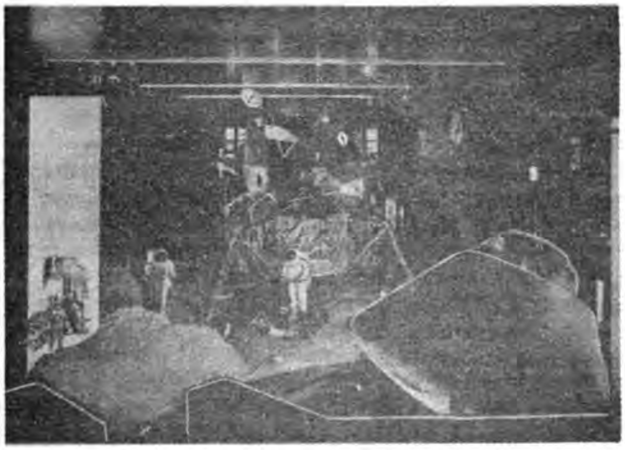
The BIS party was met on arrival by Dr. John Becklake (Fellow) who gave a brief welcome and introduction. The Science Museum, now 150 years old – really began with some of the exhibits from the Great Exhibition in Hyde Park in 1851. These were brought to South Kensington in 1856 and originally housed in corrugated-iron buildings, then known colloqually as "The Brompton Boilers," though these were later demolished and the first part of a new building completed in 1928. Even so, further extensions and modernisations are planned so that the whole Mueum is still in a dynamic state of growth.

The first space exhibit to catch the eye was the actual Apollo 10 capsule, which undertook its mission 18-26 May 1969 and which is on extended loan from the National Air and Space Museum in Washington. Nearby was a full-scale reconstruction of the Apollo 11 landing site, (complete with suitable admonition "Please keep off the Moon") together with the Lunar Lander, two space-suited figures and several experimental packages. Details of the internal fabrication of the spacesuits, e.g. water-cooled under-garments and details of toilet facilities were shown.

Also on display were 1/6th scale supporting models of Ranger and Surveyor, both examples of the many models made internally in the Museum Workshop, which employs about 50 skilled craftsmen with access to 20 different



Apollo 10 capsule.



Apollo 11 mockup.

lathes. These models are not cheap. For example, the Surveyor 7 took nearly a year to construct.

A number of models and photographs in an adjoining bay illustrated the exploration of the planets. These included a half-scale model of one of the Viking spacecraft which landed on Mars in 1976, resting on a reconstruction of the Martian surface. Next to this were models of X-ray and ultra-violet astronomy satellites, while in the front was a full-scale Skylark sounding rocket, complete with nose-cone.

Video tape recordings added a good deal to the interest of these exhibits and are so flexible that an enormous range of additional information can be provided at any time, at will.

At this point the party moved to a nearby area to see a short slide display, with commentary, on climatology, i.e. the Earth's past climate. It certainly held one's attention to see dual or triple picture projection going on simultaneously, and somewhat surprising to pick up the incidental information that vinyards flourished in England in the 12th and 13th centuries.

A number of the related exhibit areas were lit up so that members were free to browse around as they saw fit. One area featured remote sensing and included examples of results from Landsat. As several members had brought their own cameras, a number of models were brought out from their cases so that they could be seen and photographed at close range.

The second main gallery visited was the one on Astronomy. This was basically an historical collection and did not really take any account of the space age. It included the first Gregorian telescope ever made, though the Newtonian was really a replica.

The orreries and early telescopes were quite fascinating to the modern eye: their beautiful workmanship really put them more in the realm of objects d'art, suitable to grace any salon nowadays.

Adjoining this area was a small 30 seat planetarium showing stars down to the 6th magnitude and which had originally been used by the Luftwaffe in World War II to teach navigation. Members were able to see the planetarium in operation, but time did not allow for the inclusion of a full-scale show.

The final area visited was the one devoted to Space Science and Technology. It included an attractive wall display of a dozen rocket models, to 1/48th scale, including V-2, Scout, Thor, Mercury, Vostok, Saturn I, Saturn V, and even the proposed NOVA. The Black Arrow Satellite, Prospero, and a de Havilland Spectre rocket motor indicated U.K. work in this field.

Escaping the attention of most of those in the party was a small room on the first floor which has a space history all of its own. It was the room where the BIS-designed Coelostat was first exhibited. This, the world's first specifically-designed space instrument, was intended to give a stationery view of the firmament – for navigation purposes – from inside a rotating rocket, the rotation at that time being thought necessary in the absence of knowledge of the functioning of a human body in the zero gravity environment.

It was a particularly fine experience to have the whole of the Museum, to oneself it seemed. It afforded a wonderful opportunity to wander around and examine objects at leisure, free from distraction.

Our thanks are due to Dr. John Becklake and to the Department of Education (who are responsible for the Museum) for making the tour possible.

"SPACEFLIGHT" ON RADIO MOSCOW

Ralph Gibbons writes that readers may be interested to know that in response to his request to Radio Moscow for data on certain Soyuz and Salyut spacecraft, Boris Belitsky, the station's science correspondent, made the following comment over the air on 21 September 1978:

"As a matter of fact all these data have been published in the British magazine *Spaceflight*, which gives the essential data for all Soviet launchings. So I suggest you get hold of a *Spaceflight* file at some library and copy the figures out from there."

RAY WARD ON 'MASTERMIND'

Senior Member Ray Ward appeared on the BBC television quiz programme *Mastermind* on 12 October. As viewers of the programme will know, each contestant chooses a special subject, and the BBC get an expert to write questions on the subject. The contestant answers as many questions as possible in two minutes; there is then a second round of general knowledge questions. Contestants may "pass" any question, but if there is a tie at the end the winner will be the one with the least number of passes.

Ray's chosen subject was Manned Space Flight. The questions were set by Patrick Moore (BIS Fellow), and Ray says he thought them very fair – though there was a small error in one of them. (The question asked which of the original seven Mercury astronauts didn't get into space until Skylab; Ray knew this could only refer to Deke Slayton, since the other six all took part in Mercury itself, but Slayton was on ASTP, not Skylab).

The questionmaster, Magnus Magnusson, got through 20 questions in the two minutes. Ray answered 18 correctly, passed on one, and got one wrong – he says he knew them both, of course! (The pass was: Why was the landing site of Apollo 12 chosen so carefully? – answer, it was near the landing site of Surveyor 3; and the other was: What name was given to the lunar module of Apollo 12? – Ray said "Yankee Clipper," which was the name of the command module; the LM was called "Intrepid").

Ray raised his score to 28 in the second round, and at the end was tied with another contestant; but since Ray's total of passes was three and the other's was six, Ray was declared the winner. He now goes on to the semi-final; a different subject must be chosen for this, and Ray, a Chartered Librarian, has chosen Librarianship. And if he clears that hurdle too, he will be in the final, in which one may choose yet a third subject, or revert to the first-round subject, and Ray has decided that if he gets that far he will return to Manned Space Flight

SATELLITE DIGEST - 122

By Robert D. Christy

Continued from December issue, p. 438]

Introduction

Up to the end of 1978, over 1,900 launches of objects into Earth orbit or on to trajectories towards the Moon or the planets have taken place. The purpose of SATELLITE DIGEST is to document all successful launches of satellites and spacecraft, irrespective of whether they succeed in their planned missions or not. The monthly tabulation contains details of the satellite or spacecraft, where information is available; details of the launch date and time; some basic orbital information and details of the launch site and the launching rocket used.

Satellite Identification

Most satellites are given a name by the country which launches it, e.g., the Soviet "Cosmos" series and the US "Voyager" and "Pioneer" interplanetary craft. The main exceptions to this rule are military satellites launched by the US Air Force and the satellites launched by the People's Republic of China.

As well as their name, all objects are given an internationally agreed designation by the UN Committee on Space Research (COSPAR). The designation consists of the year of launch, a number corresponding to the launch during that year and a letter indicating which particular object is being referred to. For example, the 42nd Molniya-1 satellite launched on 22 August, 1978 received the designation 1978-80A. This indicates that it was the 80th launch of 1978 and that it was the payload from that launch. Three other objects went into orbit at the same time; these were the upper stage of the A-2 launch vehicle (1978-80B), the "launch platform" which oriented the satellite in space before injection into its elliptic orbit (1978-80C) and the "escape stage" of the launcher which transferred the Molniya from its parking orbit to its operating one (1978-80D).

In addition to a name and a designation, all objects receive a number allocated by the North American Air Defense network (NORAD). This number indicates its position in an ongoing catalogue of objects detected by radar. This number is not necessarily related to the order in which launches occur; Cosmos 1029 (1978-82A) was catalogued as object 11012 and its carrier rocket (1978-82B) as object 11013. The manoeuvring engine (1978-82C) which separated before recovery received the number 11018 because the launch of Cosmos 1030 had occurred in the meantime, and the intervening numbers had been allocated to it and its associated debris.

Launch Dates and Lifetimes

Usually the date of launch of a satellite is given by the launching country and in many instances, an exact time is given as well (e.g., all NASA launches, Soviet manned spacecraft and some Soviet lunar and interplanetary craft). If a launch time is not given but an orbit and launch site are known, the time of launch can be inferred by working back round the orbit to the launch site and adding on the time taken to reach orbit from the ground.

The USAF occasionally launches satellites for which both launch and orbital information is suppressed; a recent example was a satellite launched on 5 August 1978 and designated 1978-75A.

The length of time that a satellite remains in orbit depends on, mainly, the amount of energy lost by friction against the small amount of atmosphere present at orbital height. The effect of this is a gradual reduction of height until eventually the satellite encounters the denser layers of the atmosphere and burns up. Obviously, the higher the satellite, the longer its life. Satellites in highly eccentric orbits can be affected by the gravitational influences of the Sun and Moon which cause perigee height to move up and down thus subjecting it to periods of rapid orbital decay as perigee dips into the atmosphere.

Some satellite lifetimes are artificially shortened because they are caused to re-enter the atmosphere by a retrograde rocket firing. The purpose of this may be that all or part of a satellite is intended for recovery as in the case of manned spacecraft or the recoverable Cosmos satellites, or that the launching nation wishes to ensure that no part of the vehicle falls on an inhabited area of the Earth for safety or security reasons. The Salyut space laboratories and Progress ferry craft are commanded to re-enter over the Pacific Ocean at the end of their working lives. Sometimes, attempts to cause a satellite to re-enter fail with embarrassing consequences as in the case of Cosmos 954. SATELLITE DIGEST attempts to include the dates of decay from orbit of all the satellites listed and to indicate whether re-entry was natural or artificially caused and in the latter case to show whether recovery was intended.

Satellite Dimensions

Payloads come in all shapes and sizes, varying from the French laser-reflecting Starlette – a 0.26 m diameter sphere weighing 47 kg – to the 26 m long, 75 tonne cylinder of Skylab. Where details of a satellite's size and shape are given, these are listed. In cases where information is not directly available as with most of the Cosmos satellites, estimated values for the size and mass are given, based on comparison between the known details of the launch and previously released information about earlier, similar craft. Where estimates are involved, entries in the table are accompanied by a question mark.

Orbital Information

The entries in SATELLITE DIGEST covering satellites' orbits are based on orbital elements distributed by NASA's Goddard Space Flight Center. Apogee and perigee heights are quoted with respect to a spherical Earth of 6378 km radius which is the mean equatorial radius of the true Earth. The mean polar radius of the Earth is approximately 21 km less than this. Perigee and apogee represent respectively the points in an orbit which are nearest and furthest from the Earth.

Care must be taken when comparing heights listed in SATELLITE DIGEST with those quoted by other sources because data may not relate to the same "standard Earth." An example of this is found by comparing information released by the *Novosti* press agency about the orbit of Soyuz 31 with the entries in SATELLITE DIGEST. According to *Novosti*, an orbital correction after launch resulted in a perigee of 271 km and an apogee of 326 km; the corresponding figures in the DIGEST entry are 256 and 321 km respectively. The reason for the difference is that the heights in the *Novosti* announcement are measured with respect to the true surface of the Earth and also taken into account the fact that the Earth is pear shaped and that there is more mass north of the equator than there is south of it. A consequence of this last fact is that once a satellite has been placed in orbit, its perigee moves round the orbit at a rate which depends on the orbital inclination and as it moves from north of the equator to south and back again, perigee height varies because of the uneven mass distribution. A difference in orbital information quoted by separate sources does not necessarily imply that a manoeuvre has taken place.

The inclination of a satellite orbit is the angle between the plane of the orbit and the plane of the Earth's equator. It is measured at the point where the satellite crosses the equator in a northbound direction and the angle is measured from east through north. A satellite orbiting above the equator in an easterly direction has zero inclination, one passing over the poles has an inclination of 90° and inclinations in excess of 90° indicates that the equator crossing was in a north westerly direction.

The time taken by a satellite to complete one orbit increases with height; SATELLITE DIGEST lists the nodal period, which is the time between successive northbound equator crossings. Other sources may list the anomalistic period, which is the time taken to travel from perigee to perigee; it differs from the nodal period by an amount determined by the rate at which perigee moves round the orbit. For inclinations less than 63.4°, the anomalsitic period exceeds the nodal one, at 63.4° the two are the same and above that value, the nodal period is the higher. The Molniya satellites use inclinations close to the 63.4° value in order that only a very small amount of orbit adjustment is required to keep perigee in the southern hemisphere.

Launch Sites and Launch Vehicles

The policy of launching agencies on revealing these details is variable. US sources are quite open but the Soviet Union is less forthcoming and details are derived from comparison with previous launches, study of photographs of launch vehicles and relating initial orbits' ground tracks to known launch sites. In all cases, the origin of the payload or the launch is known because of the source of the launch announcement.

Abbreviations

A number of common abbreviations are used in SATELLITE DIGEST to denote launching agencies, payload manufacturers, etc. Some of them are listed below. When new ones occur, they are explained in the particular issue of the table.

DoD – Department of Defence.

ETR – Eastern Test Range, Florida.

NASA – National Aeronautics and Space Administration.

NOAA – National Oceanographic and Atmospheric Administration.

USAF – United States Air Force.

USN – United States Navy.

WTR – Western Test Range, California.

A note (R) in conjunction with a satellite lifetime indicates a successful recovery of a payload.

The abbreviations for Soviet launch vehicles "A-2," "C-1," etc. are from the Sheldon classification system.

Supplementary Notes

Where available, information on the purpose of a satellite is included at the end of the table. The notes are extracted from news releases, newspaper articles and from both popular and specialist magazines. As satellites decay, more orbital information becomes available or data is refined; appropriate notes for updating previous DIGEST issues are also included.

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Molniya-1 (42) 1978-80A 11007	1978 Aug 22.99 12 years?	Cylinder-cone + 6 panels + 2 antenna 1000?	3.4 long 1.6 dia	442 462	40792 39915	62.87 62.83	735.69 718.24	Plesetsk A-2-e USSR/USSR (1)
Soyuz 31 1978-81A 11010	1978 Aug 26.69 67.843 days (R) 1978 Nov 2.462	Sphere + cone-cylinder + antennae 6600?	7.5 long 2.3 dia	193 256 337	243 321 355	51.62 51.63 51.63	88.80 90.22 91.40	Tyuratam A-2 USSR/USSR (2)
Cosmos 1029 1978-82A 11012	1978 Aug 29.62 9.69 days (R) 1978 Sep 8.31	Cylinder + sphere + cylinder cone? 6000?	6 long? 2.4 dia?	177 169 169	331 297 357	62.82 62.80 62.82	89.59 89.16 89.76	Plesetsk A-2 USSR/USSR (3)
Cosmos 1030 1978-83A 11015	1978 Sep 6.12 12 years?	Cylinder-cone + 6 panels + antennae? 1000?	3.4 long? 1.6 dia?	610 617	40128 39749	62.78 62.83	725.57 718.02	Plesetsk A-2-e USSR/USSR (4)
Venera 11 1978-84A 11019	1978 Sep 9.15 indefinite	Sphere-cylinder + 2 panels + antenna? 5000?	5 long? 2.5 dia?	152	181 heliocentric orbit	51.55	87.76	Tyuratam D-1-E USSR/USSR (5)
Cosmos 1031 1978-85A 11022	1978 Sep 9.62 12.61 days (R) 1978 Sep 22.23	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	182 170 165	347 313 342	62.84 62.82 62.82	89.59 89.34 89.58	Plesetsk A-2 USSR/USSR (6)
Venera 12 1978-86A 11025	1978 Sep 14.10 indefinite	Sphere-cylinder + 2 panels + antenna? 5000?	5 long? 2.5 dia?	150	175 heliocentric orbit	51.55	87.67	Tyuratam D-1-E USSR/USSR (7)
EXOS B 1978-87A 11027	1978 Sep 16.20 5 years?	Cylinder 100	0.8 long 0.95 dia	228	30051	31.10	523.17	Kagoshima Mu-3H Japan/Japan (8)
Cosmos 1032 1978-88A 11029	1978 Sep 19.33 12.9 days (R) 1978 Oct 3.2	Sphere + cylinder-cone?	5 long? 2.4 dia?	214	223	81.35	89.02	Plesetsk A-2 Plesetsk

Supplementary notes:

(1) 42nd operational Molniya-1 type communications satellite; orbital data are at 1978 Aug 23.6 and 1978 Aug 29.7.

(2) Carried the third international crew to Salyut 6. Soyuz 31 docked with the port on Salyut's instrument unit at 1978 Aug 27.7. The crew commander was Col. Valery Bykovsky, who had previously flown in Vostok 5 and Soyuz 22, and his companion was cosmonaut-researcher Sigmund Jähn of the German Democratic Republic. After a flight of 7.9 days, Bykovsky and Jähn returned to Earth in Soyuz 26, landing at 1978 Sep 3.5. At 1978 Sep 7.45, the Soyuz 29 crew entered Soyuz 31, undocked from Salyut 6 and after the station has been rotated, they re-docked with the forward docking unit, leaving the aft one free for further fuel-carrying Progress craft. Orbital data are at 1978 Aug 26.8, 1978 Aug 27.1 and 1978 Aug 27.8.

(3) A redundant manoevring engine (1978-82C) was separated from Cosmos 1029 during 1978 Sep 7. 1978-82C decayed 1978 Sep 11.70 and a 20 kg fragment, roughly spherical in shape was recovered near Moulins in France (46.6 deg N, 3.5 deg E). Orbital data are at 1978 Aug 29.8, 1978 Sep 5.2 and 1978 Sep 6.1.

(4) Probably a missile early warning satellite, similar to 1978-66A (Cosmos 1024). Orbital data are at 1978 Sep 6.7 and 1978 Sep 14.7.

(5) First of a pair of Venus exploration craft launched during the 1978 window, Venus encounter to take place during 1978 December. The orbit shown is that of the orbiting launch platform, 1978-84B.

(6) A redundant manoeuvring engine (1978-85D) was separated from Cosmos 1031 during 1978 Sep 21. Orbital data are at 1978 Sep 9.7, 1978 Sep 11.2 and 1978 Sep 17.1.

(7) Second of a pair of Venus exploration craft (see note 5). The orbit shown is that of the launch platform, 1978-86B.

(8) Japanese research satellite, also known as Jikiken (Magnetosphere). It carries scientific experiments for plasma, charged particle and electric and magnetic field studies.

Amendments and decays:

1971-60A decayed 1978 Aug 31, lifetime 2603 days.
1973-45D, the sixth Molinya 2 decayed 1978 Aug 5, lifetime 1851 days.
1976-49A, Cosmos 822 decayed 1978 Aug 8, lifetime 802 days.
1977-51A, Cosmos 919 decayed 1978 Aug 28, lifetime 436 days.
1978-52A, Cosmos 1010 carried a supplementary scientific package which separated during 1978 Jun 4, designation 1978-52C.
1978-61A, Soyuz 29 landed 1978 Sep 3.5, lifetime 79.7 days.
1978-75A is a further US military mission for which orbit and launch data is being withheld; see also 1977-38A, 1976-80A for further examples.
1978-76A, Cosmos 1028 separated a redundant manoeuvring engine (1978-76D) during 1978 Sep 3. The satellite itself manoeuvred several times during its flight, on average once every 5 days.
1978-77A, Progress 3: the orbital data listed in last month's table are at 1978 Aug 8.1, 1978 Aug 8.4 and 1978 Aug 10.3.

SCIENTIFIC SATELLITE EXOSAT

The European Space Agency has decided to award the contract for the development (phases C and D) of the scientific satellite EXOSAT to the European Consortium COSMOS, led by Messerschmitt-Bolkow-Blohm, Germany. The Prime Contractor is supported by Co-Contractors ETCA (Belgium), Aerospatiale (France), MSDS (United Kingdom) and SELENIA (Italy), in charge of sub-system design and development.

The contract, worth a total amount of 46.5 MAU, covers the development, integration and testing of the satellite.

EXOSAT is an orbital observatory for the measurement of the position, structural aspects and spectral and temporal characteristics of X-ray sources. It will carry a payload comprising four experiments: two imaging telescopes for low energy X-rays, a large area proportional counter array, and a gas scintillation spectrometer both for medium energy X-rays.

The experiment units are developed mainly by European industry under the direction of ESA's Space Science Department, with the collaboration of the following Scientific Institutes:

- Max Planck Institute at Garching (Germany).
- Mullard Space Science Laboratory and Leicester University (United Kingdom).
- University of Palermo and the LFCTR of the National Research Council at Milan (Italy).
- Cosmic Ray Working Group of Leiden and the Utrecht Space Research Laboratory (Netherlands).
- High Energy Astrophysics Division, Space Science Department, ESA.

The observatory will be mounted on a three-axis-stabilised satellite and placed in a highly eccentric orbit, whose apogee - roughly above the North Pole - will be at an altitude of 200,000 km.

EXOSAT should be launched in the 2nd quarter of 1981 by the European launcher, Ariane, which on this occasion will be equipped with a fourth stage to enable the satellite to reach the orbit required for its mission.

KONSTANTIN BUSHUYEV

The death of Professor Konstantin Bushuyev, who played a leading role in the Soviet space programme, was announced on 28 October 1978.

A noted designer of space rocketry, Professor Bushuyev was a close associate of the late Academician Sergei Korolev and was the Soviet director of the Apollo-Soyuz Test Project.

An obituary signed by Leonid Brezhnev and other Soviet leaders acknowledges the great contribution he had made to the exploration of outer space. His theoretical and practical experience, it said, was well shown by his work in developing and building automatic spacecraft for the exploration of near-Earth space, the Moon and the planets Venus and Mars, and in piloted spaceships.

WHERE ARE THEY NOW?*/Continued from p. 13]*

water of Shuttle/Spacelab EVA operations and emergency procedures.; also Head of "design support" group Astronaut Office.

WORDEN, Alfred M., Lt. Colonel USAF (Ret.). Born 7 February 1932, Jackson, Michigan. Divorced, two children, subsequently remarried. Astronaut Support Crew for 'early' Apollo missions and for Apollo 9; backup CMP Apollo 12; CMP Apollo 15, 26 July-7 August 1971, first man to conduct a deep space EVA; subsequently became a research-test pilot at NASA Ames Research Centre May-September 1972 when he was assigned as Director of Advanced Research and Technology, Systems Studies Division, NASA Ames Research Centre, Moffett Field, California; he also served as a senior scientist there. Retired from both NASA and USAF on 1 September 1975 and since 5 September 1975 has been Vice-President of High Flight Foundation, Colorado Springs, Colorado, and Director, Energy Management Programs, Northwood Institute, Palm Beach, Florida. From 1973-July 1975 he participated in NASA's Outlook for Space 1980-2000 study group.

[To be continued.

CORRESPONDENCE

Our New Headquarters – A 19th Century Pipe Dream?
Sir, Fragments of the past in the shape of four clay pipes were recently found at the site of our new Headquarters. From their shape and design they hint at possibly two interesting periods in the course of the area's development, and may indicate something about the people who used them. Outline sketches of the fragments, approximately full size, are shown in the accompanying illustration.

Three of the pipes are "navvies clays", made for the hard rough and tumble of a labourer's life. The bowls and stems are very thick and strong, built to withstand being tapped out on a handy stone or brick, and being clamped firmly between the teeth when its owner was working. Even though it was sturdily built, one pipe bowl was broken and it seems to have been smashed while tapping out after smoking. Another seems to have hardly been used before being broken along the stem.

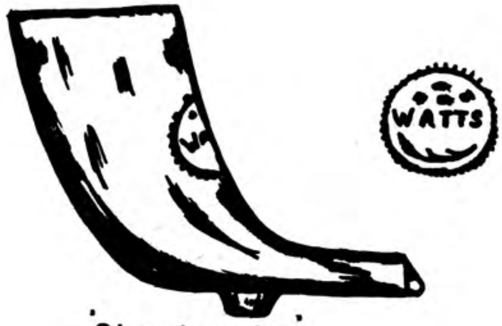
From their shape, they could well have been made in the mid-19th century and, hazarding a rough guess, may have been left by the navvies engaged on building the Albert Embankment, or the main drainage of the area. They are definitely working men's possessions.

The fourth pipe is of a different category. The bowl is of a more delicate and shell-like design: the top of the bowl is not parallel with the stem and the slope of the bowl to the stem is greater – see sketches. This could indicate that it was probably a "churchwarden," i.e. a pipe with a long stem, held between finger and thumb and used in 'contemplative' smoking. The bowl of the pipe is very well stained both inside and out indicating that it was a well used over a long period. This is confirmed by the smooth finger and thumb grease stains on either side of the bowl's exterior.

On the bowl is the maker's name and trade mark "WATTS" set in a rising Sun motif with a sprig of leaves underneath. If anyone can forward information on the Watts Company that made clay pipes, we would be interested in quoting the details. From its appearance and design this pipe possibly dates from an earlier period – maybe the first quarter of the 19th century – so its owner would have seen many changes in the area.

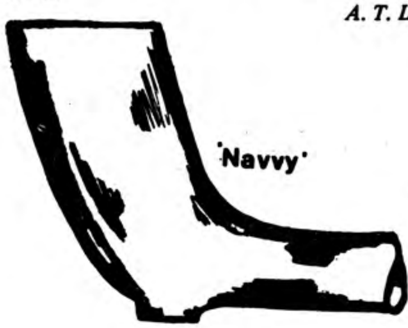
Perhaps, as he smoked, he occasionallyglanced at the stars and wondered about them but he could never have dreamed that, on that very spot, would one day arise the Headquarters of a Society destined to produce engineering designs for starships.

A. T. LAWTON.



Drawings of two of the clay pipes found on the site of the new BIS headquarters in Lambeth.

A. T. Lawton



New Headquarter Buildings
Sir, I hope the plans for the construction of the new headquarters includes a sprinkler system. The reason for my concern is, the San Diego Aerospace Museum lacked sprinklers and on 22 February 1978, a fire destroyed the building. After all the work that everybody is putting in, it would be a tragedy if a similiar fate befell the headquarters.

CURTIS PEEBLES
El Cajon, California, U.S.A.

We put the question of a sprinkler system to our Architect He advises us as follows:

Your letter of 20 July asks about a sprinkler installation, and requests advice. My advice to you is NOT to have a sprinkler system installed, for the following reasons:-

(1) It is a very expensive thing to instal, consisting of hundreds of feet of steel tubing fixed to the ceiling, with outlets at about 6′0″ centres. The tubing is connected to the water main supply, and unless covered by a false ceiling, will be ugly.

(2) If it is actuated, the thousands of gallons of water discharged would completely destroy the contents of the building.

A better system is one based on the use of a vapourising liquid which produces either CO_2 gas, or Haylon gas, which forces all oxygen out of the room and prevents combustion. These are actuated by smoke detectors in the rooms required to be protected, and consist of steel bottles 9″ diameter and 4′0″ long which are stored in the protected rooms and coupled to delivery tubes.

I should advise you that both CO_2 and Haylon gases are noxious and could be poisonous, and that unless you expect to have articles of great value in the building, NOT to have such a system installed.

Because we are bound by law to take the necessary fire precautions including rigorous adhesion to NO SMOKING rules, the fire prevention scheme is adapted to fill three purposes:

(1) Smoke detectors and alarm bells to give early warning, and

(2) the provision of ½ hour fire resistant, self closing, non locking doors everywhere, to facilitate easy escape, and

(3) the provision of fire tight lobby approaches to all rooms, intended to contain a fire and smoke should it occur.

G. J. HELLIWELL.

Supersonic

Sir, Thank you very much for sending the back issues of *Spaceflight* and may I compliment you on your excellent service? I posted the money order to you on Monday 18th and received the 1976 back issues on Thursday 21st. Well done!

JOHN STATHAM,
Chingford, London,

'Spaceflight' Quality

Sir, Please let me congratulate you on the high quality of your magazine. I receive 11 or more space magazines and journals and yours seems to be the most informative and superbly written. Thank you!

DENNIS KOCHER,
Sacremento, California, USA.

A British Enterprise

Sir, I've just received my copy of Project Daedalus (Final Report), without reservation a most awe inspiring document.

If such a small group of people can create as viable a concept as this, in their spare time, just think of the possibilities of interstellar flight if it were their life's work!

This Publication landmark in scientific thought makes me proud to be a member of the BIS.

K. J. O'BRIEN,
St. John's, Newfoundland, Canada.

Daedalus a Landmark!

Sir, Thank you for sending the copy of the Project Daedalus Report. It is indeed an impressive document! What a tribute to the teams of dedicated BIS members who participated, volunteering months of personal time and effort.

In my opinion the Daedalus Report will prove to be a landmark, a basic reference for those who study stellar travel in the decades ahead. Congratulations to all concerned.

Enclosed is a further donation toward the BIS Building Fund.

FREDERICK C. DURANT, III,
Concord, Massachusetts, USA.

Project Daedalus

Sir, I received a copy of *Project Daedalus* today and I am writing to express my appreciation at the very efficient way in which you dealt with my order; a total of *two* days between my sending the order and receiving the goods; excellent! If only some of such a high degree of efficiency prevailed in Industry we might regain some of our lost reputation as a Nation.

The report itself is well set-out with clear type and sharp line drawings. I am looking forward to reading it.

D. G. McGARRY,
South Tottenham, London.

Scarves and Ties
Sir, Thank you for sending my two BIS scarves. I am very pleased with them and wonder why the Society did not think of the idea long before now. You have only to look at the schools and colleges to see that the scarf is usually around the same time as the blazer badge and the tie.

ALAN JONES,
Islington, London.

Plutonium Mishap
Sir, Much concern was expressed earlier this year about possible effects of radiation from the crashed Cosmos 954 sea-surveillance satellite. The uranium-235 fuelled electrical generator which powered the spacecraft is thought to have been destroyed during re-entry. Wreckage was discovered over a wide area of Canada's Northwest Territories but only a scattering of radioactive particles was found.

However, it is interesting to note that a similar, but much less publicised event, occurred eight years earlier in April 1970 during the last hours of the Apollo 13 aborted lunar mission. Then, 8.36 lb of radioactive plutonium-238, which was intended to be the power source for the SNAP-27 generator on the Moon, re-entered the Earth's atmosphere and fell into the Pacific Ocean northwest of New Zealand.

The cask in which the fuel was stored was protected by a heat shield and so survived the entry through our atmosphere, while the lunar module to which it was attached burned up. The cask of plutonium is believed to have fallen in 2,700 fathoms of water somewhere near latitude 25°S, longitude 174°W and at present is not an immediate danger.

REFERENCES

1. *Sky & Telescope*, June 1970, p. 350.
2. *Flight International*, 4 February 1978, p. 278.
3. *Flight International*, 2 May 1978, p. 1643,
4. K. W. Gatland, *Manned Spaceflight*, Blandford, 1976.

KEITH WILSON,
Hamilton, Strathclyde, Scotland.

Space Telescope – 1
Sir, May I say how much I enjoyed the Sept-Oct 1978 issue of *Spaceflight*. The article by Kenneth Gatland on Harry Ernest Ross was excellent and awoke old memories. Then the BIS Educational Supplement article by Dr. C. R. Dell, "The Space Telescope," was certainly an education and of great interest, followed by Geoffrey Lindop's contribution filling in the details. The drawings also were most explicit. In fact the whole thing was so exciting I could not put it down.

I was so glad to read that the European contract covered a great deal of the Telescope project and that the U.K. is to be allowed to develop parts of the telescope at Bristol in co-operation with NASA. I do so hope Britain will get a larger share of space development and manufacture than in the past.

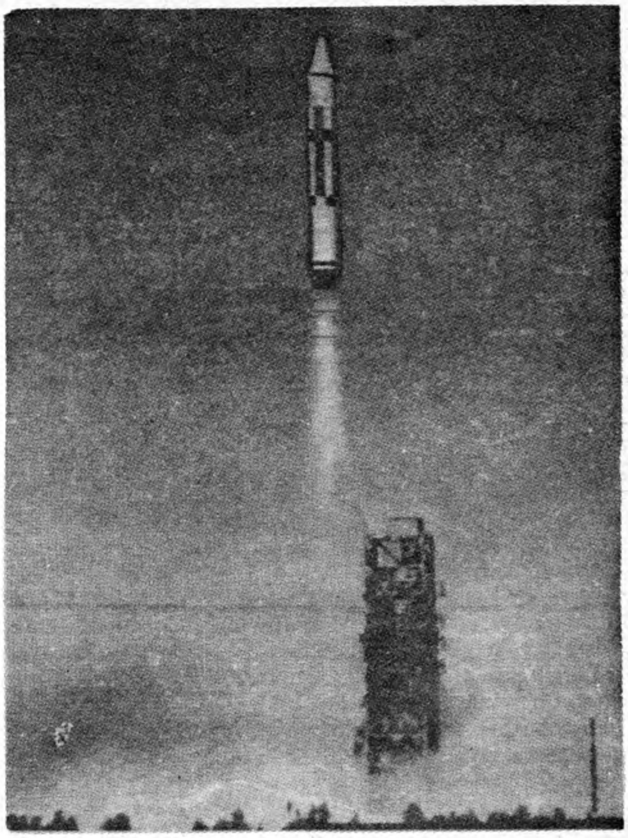
Anyway thank you for this excellent magazine.

ELSIE M. VINCER,
Newquay, Cornwall.

Space Telescope – 2
Sir, I very much appreciate your sending me copies of the Sept-Oct issue of *Spaceflight*. The detailed article on Space Telescope will be a very useful reference.

It is the most authoritative article I have seen so far on this fascinating subject.

T. C. BICKERTON,
Publicity Officer – Bristol Division,
British Aerospace, Dynamics Group,
Bristol.



Chinese Ballistic Missile
Sir, In the 2 August 1978 edition of *New China News* I discovered this photograph of a Chinese launch vehicle. The caption on the picture says it is a "guided missile launched by a unit of the Chinese People's Liberation Army."

I can't recall having ever seen a picture of a Chinese vehicle of this size. Has any body else? What can the BIS launch vehicle experts deduce from it?

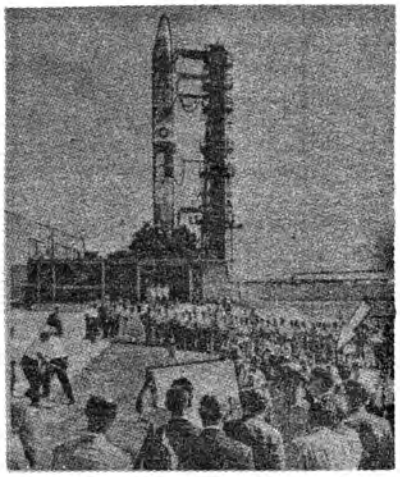
Might I also add a note of information for BIS members travelling in China? On the road to the Great Wall, from Peking, is a large tracking station. While there last year my Chinese guide only mentioned it after it was too far behind us to be seen. I should have asked earlier: BIS members travelling the Far East should keep an eye out for it.

RICHARD MACEY,
Canberra, Australia.

Presumably the photograph was taken at the Chinese test centre at Shuang-Ch'eng-tze, Inner Mongolia (approximately 41 deg N latitude, 100 deg E longitude). The service gantry shown is similar to structures used by the United States in launches of the early 1960's. At first glance the rocket itself resembles the USAF Titan 2 ICBM but could be smaller. There is little to indicate its true size. Titan 2, a two-stage rocket, employs storable propellants N_2O_4 and Aerozine 50, a mixture of 50 per cent hydrazine (by weight) and unsymmetrical di-methyl hydrazine. With the GE Mk 6 warhead it stands 103 ft (31.4 m) tall and has a diameter of 10 ft (3.05 m). The photograph on page 47 was taken on 11 September 1962 during preparations for an above-ground test at Cape Canaveral when the late President Kennedy (arrowed) toured the site. Ed.

Left, first photograph of a Chinese ballistic missile. The rocket bears a superficial resemblance to the U.S. Air Force Titan 2 ICBM (*right*) but could be smaller.

New China News Agency/U.S. Air Force



Naming Extraterrestrial Features

Sir, I share the views of Mr. Robert Gibson (*Spaceflight*, August 1978, p. 319) in that we are in danger of misnaming features on other planets and their satellites, simply by running out of names.

I should point out, however, that the lunar crater Birmingham is not named after the city but after John Birmingham a nineteenth century Irish selenographer, and I do feel that the danger of Clacton on Callisto is not so imminent as he fears.

Nevertheless, it is estimated that another 500 names need to be found for lunar craters, and the task of charting Mars and Mercury has only just begun. Ideally each crater should be given a name as soon as it is discovered, but this would be an impossible task. Furthermore a name once given has to remain indefinitely. The alternative is simply to give each crater an international designation number – but quite frankly it makes life boring.

I am working currently on a project of giving each lunar crater a code name (pending the adoption of a proper name). It is too early for me to draw any conclusions from my project, but readers might be interested in my method.

First of all the selenographic longitude and latitude of the craters and their diameters are determined. To each degree I assign two constanants, and to each increment of diameter by one kilometre I assign three vowels. Above 100 kilometres the increments are in ten-kilometre steps simply to conserve the number of permutations over the whole range of lunar craters.

For example crater Plato F is at latitude 51 North. This corresponds to the consonants 'RF,' which form the first and third characters of the code name. The longitude of Plato F is 17 West to which I allocate 'LN' being the fifth and seventh characters. The diameter of Plato F is 7 kilometres and 'AEO' form the second, fourth and sixth characters of the codename. In this way the name becomes prenouncable. Plato F in my code becomes RAFELON, and Bianchini W becomes RABAKUW. The system has the advantage that names can be generated for all the craters above one kilometre in diameter pending the allocation of a proper name which might honour the name of a great scientist. It is important to leave some leaway for future generations to honour their scientists and not be rushed into naming all the features discovered simply to fill the map with names.

From the code name it is easy to grasp where the crater is, and how big it is without referring to a separate catalogue. Furthermore craters beginning with the letters G to T are on the nearside, and those whose second character is 'U' have diameters over 100 kilometres, although most of these have proper names.

I have not extended my project to other planets as yet, but I imagine that the range of diameters might present some problem. I am also working on a similar scheme for naming stars for astronauts of the future, since the star *Alpha Centauri* will no longer be in the constellation of *Centaurus* when the first starship arrives there. It would be better to refer to this star by the arabic 'Rigil Kent,' but we would soon run out of arabic names. A prime example is Lalande 21185, which ought to be renamed before the start of interstellar travel!

GEOFFREY HUGH LINDOP,
Kirkbride, Carlisle.

Pluto's Moon

Sir, The discovery of Pluto's moon, Charon, shows us once again how little is known about the outer Solar System. One particularly interesting observation is that Charon might well have a diameter which is 40 per cent that of Pluto [1]. This indicates that what we have here is a "double planet." The Earth-Moon system provides the only similar situation in the Solar System where the size of the satellite is a large fraction of that of the planet. Hence the Pluto-Charon system offers a fascinating comparison with the Earth-Moon system. Improved data from the Pluto-Charon system may give fresh insights about the Earth-Moon system.

Unfortunately it seems that decisive proof of the existence of Charon has yet to be obtained as it has still not been seen separately from Pluto in even the best photographs [1]. The great distance and small size of Pluto make it a difficult object for study from the Earth's surface. Unhappily there seems to be no prospect of sending a fly-by mission to Pluto in the near future. With our present technology such a spacecraft would take a prohibitively long time to reach the planet. The idea of getting to Pluto in a much more reasonable time (8 years instead of 41 [2]) by going *via* Jupiter and Saturn after a launch in the 1976-1980 period was discussed at the Jet Propulsion Laboratory, Pasadena, California in 1969 [3]. This opportunity seems to have been lost.

However, another spacecraft, one which will be in Earth orbit, could provide some help. This is the NASA Space Telescope which with luck will be placed in orbit by the Shuttle in 1983. The Space Telescope would certainly give us more knowledge about Pluto and Charon because it will have an aperture of 94 in. whereas it was possible to discover Charon using the 61 in. reflecting telescope at Flagstaff, Arizona. Amongst other advantages of the Space Telescope for this work would be its capability to point anywhere in the celestial sphere and its ability to observe objects 50 times fainter than possible from the ground [4]. I note that "detailed studies of planets" is one of the key areas of study identified for the use of the Space Telescope [4]. One other reason why this particular project should be included in the plans for the Space Telescope is that the perihelion of Pluto in 1989 will fall during the projected 10-15 years lifetime of the Space Telescope. Certainly the closest approach of Pluto is an opportunity which should not be missed.

J. D. HUGHES,
Waterloo, Liverpool.

REFERENCES

1. Ian Ridpath, "Pluto looks smaller than ever," *New Scientist*, p. 273, 27 July 1978.
2. Peter Ryan, *The Invasion of the Moon 1969*, Penguin, pp. 165 and 167.
3. Patrick Moore, *The Sky at Night 3*, B.B.C.
4. *Spaceflight*, 20, 3, p. 105.

Future Assured

Sir, "Space – The Final Frontier" – to quote from the introduction to a popular science-fiction television series. But how true this is, for what could possibly lie beyond? Programmes of this nature may come and go but the allure of deep space remains, as it has done for centuries.

Frontiers have already been pushed back, but in his thirst for knowledge – not to mention his insatiable curiosity – man will keep pushing, never deviating until the last barrier has been broken.

A formidable task? Yes, but not one to daunt the human spirit!

The exploration of space is the most awesome that mankind has ever undertaken. Man has always risen to any challenge that has confronted him in the past, for without this sense of adventure the human race would surely stagnate.

And in this, the greatest challenge of all, man has not been deterred by the immensity of the path ahead, on which he has taken but one small step.

As each generation breaks new frontiers, the barriers remaining will still be enormous and challenging as ever, a virtual guarantee that the future of the human race is assured for, clearly, what greater challenge can there be than that of the Universe itself?

It is regretable that governments see fit to devote so little of their national budgets to this inspiring cause, for it is not only their future they are assuring but that of all of us.

There will be dangers and disappointments ahead but also, I have no doubt, incredible rewards.

Our generation has laid the foundation on which all future space programmes will be built. The wheels have been set in motion for the greatest endeavour ever undertaken in the history of mankind. It cannot fail. It will not fail. For generations to come man will surpass the achievements of his predecessors, set steadfastly on the course towards greater understanding set by his forebears centuries before.

We are indeed fortunate that the dawning of the "Space Age" occurred in our time. In the centuries to come, what greater tribute can there be from the scientists of that day than to the pioneers of the space programme today who took their first faltering steps from the cradle of Mother Earth with a courage and determination that could do nothing else but inspire those who followed: those dedicated men and women of our generation who believed, not only in themselves, but in all mankind.

IAIN R. SIMPSON,
Hamilton, Bermuda.

Mr. Simpson describes himself as a "layman" member of the Society "suitably impressed by the depth of knowledge and talent both of your contributors and readers whose articles and letters appear in 'Spaceflight'." With them " he shares a deep and burning desire to see that science and space research and technology advance as quickly as possible."

"Where Are They Now?"

Sir, In reply to Ray Ward's letter concerning the first part of my series "Where Are They Now?" (*Spaceflight*, July 1978, pp. 272-275), may I clear up the problem of how many astronauts are left on the active flight list?

Total astronauts selected in the seven groups come to 73; eight of these are now dead, leaving 65. At the present time a total of 27 astronauts remain on the active flight list participating for the forthcoming Space Shuttle programme. A further three (Pogue; Schweickart; Swigert) are on Government assignments or leave of absence, and are classed as Inactive, but available for Space Shuttle missions. Therefore overall total of astronauts still on availability lists is 30. (Not 31 as I stated in my article). The figure 31 came from the fact that although Allen has a Government assignment he is listed as Active by NASA. Of these 27 men, 16 are civilian and 11 military; again of these 27, 17 are pilots (the three Inactive are all pilots bringing the total to 20; the other 10 (which include Pilot-astronaut Lind) are scientist astronauts.

The remaining 35 are no longer associated with the Astronaut Corps of NASA although some still work for the agency.

So it is clear the 22 pilots should read 21 (with three inactive) and 10 scientists totalling 30 (27 active), 35 resigned or retired and 8 deceased.

DAVE SHAYLER,
Small Heath, Birmingham.

Disposition of Apollo Hardware

Sir, Following David Baker's compilation of the deposition of Apollo hardware [1] and my later letter [2] on the same subject, I have noted the following changes (with Baker's listing in quotation marks):

CM-103 (Apollo 8)	On display in the Museum of Science & Industry, Chicago.
CM-108 (Apollo 12)	"To Smithsonian." Now on display at Langley Research Center's visitor area.
CM-112 (Apollo 15)	"At Rockwell International." Now on display at the Air Force Museum, Dayton, Ohio.
CM-114 (Apollo 17)	On display at the Johnson Space Center, Houston.
CM-116 (Skylab 2)	Having carried its all-Navy crew to repair the crippled Skylab, this CM is displayed in the Naval Air Museum, Pensacola, Florida.
CSM-119	CSM-119 acted both as Skylab and ASTP backup and is now on display in the simulator building at Kennedy Space Center, together with LM-9 [2].
S-IB-11 (First stage of SA-211)	"In storage Michoud Assembly Facility." At present, the vehicle is at the Marshall Space Flight Center but it is to be erected at the side of Governors Drive in Huntsville, Alabama, home of the Saturn boosters. Upper stage is probably S-IVB-11.
S-IB-12 (First stage of SA-212)	This was on display at the Visitor Information Center at Kennedy Space Center but has been removed.

ANDREW WILSON,
Rotherham, S. Yorkshire.

REFERENCES

1. *Spaceflight*, April 1974, pp. 137-139.
2. *Spaceflight*, March 1977, p. 118.

JBIS journal of the british interplanetary society

The 12 monthly issues of *JBIS* for 1979 cover a wide range of technical space topics and with special selections on: *SPACE SCIENCE AND EDUCATION; SPACE TECHNOLOGY; SPACE APPLICATIONS; SPACE HISTORY and INTERSTELLAR STUDIES.*

The contents of the issues which have been published since the last list (Spacecraft, Dec 1977) are given below.

Members can obtain the 12 copies of *JBIS* for 1979 for £11.50 ($23.00) postage inclusive. The four *INTERSTELLAR STUDIES* issues can be obtained separately for £4.00 ($8.00). Single copies of any issue may be purchased at £1.00 each ($2.00) post free.

Orders can be included in the annual subscription renewal notice or sent separately to:
Executive Secretary, British Interplanetary Society,
12 Bessborough Gardens, London, SW1V 2JJ, England.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 12 Bessborough Gardens, London, SW1V 2JJ: Tel: 01-821 9371.

Correspondence and manuscripts intended for publication should be addressed to the Editor 12, Bessborough Gardens, London, SW1V 2JJ.

Opinions in signed articles are those of contributors, and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Visit

A second opportunity to tour the Astronomy and Space Galleries of the Science Museum, Exhibition Road, London, S.W.7., for those unable to participate first time around, will be given on **17 January 1979** at 6.30 p.m.

As before, the group will be accompanied by Dr. John Becklake.

Admission (restricted to members only) will be by ticket only, available from the Executive Secretary enclosing a **reply-paid envelope.**

Short Paper Evening

Title **EXOTIC SEMI-CONDUCTOR MATERIALS**
by A. T. Lawton

Title **INTERSTELLAR COLONISATION**
by Dr. L. J. Cox.

To be held in the Kent Room of Caxton Hall, Caxton Street, London, S.W.1. on **1 February 1979,** 6.30-9.30 p.m.

Admission tickets are not required. Members may introduce guests.

Visit

Arrangements are being made for a small party of members to visit the Rocket Propulsion Establishment at Westcott, Nr. Aylesbury, Bucks. on **14 February 1979** *(all day).*

The excursion will be by train to and from Aylesbury (departure Marylebone Station).

Registration is necessary. Members interested in participating *must* apply to the Executive Secretary, enclosing a **reply-paid envelope,** no later than **28th January** 1979.

Western Branch

Topic **FILM SHOW**

To be held in the Physics Lecture Theatre, G.4Z, Tyndalls Avenue, University of Bristol, on **2 March 1979** at 7.15 p.m.

The programme will be as follows:

(a) Remote Possibilities
(b) The Weather Watchers
(c) If One Today, Two Tomorrow
(d) The Mission of Apollo-Soyuz

Admission tickets are not required. No University car parking facilities are available but there are Public Car Parks at Park Row, Berkeley Place and limited road parking around the University Precinct.

General Meeting

Title **SPACE MISCELLANY – 2**

To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **8 March 1979,** 6.30-8.30 p.m.

Two contributions will be presented:

(1) Phil Parker will travel down memory lane with Apollo Reminiscences

(2) David Early will discuss and exhibit some of his Space Paintings.

Admission tickets are not required. Members may introduce guests.

Lecture

Title **ASTRONOMY FROM ORBIT**
by Dr. W. I. McLaughlin (*J.P.L.*)

To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **4 April 1979,** 6.30-8.30 p.m.

Admission tickets are not required. Members may introduce guests.

16th EUROPEAN SPACE SYMPOSIUM

Theme: **CURRENT AND POTENTIAL EUROPEAN SPACE PROJECTS**

To be held in Stresa, Northern Italy, on 3rd - 5th July, 1979, co-sponsered jointly by the DGLR, AAAS, AIDAA and BIS.

Technical Sessions will be devoted to the following main subject areas.

(1) Spacelab and Supporting Activities
(2) Technology of Space Vehicles (Satellites and Launchers)
(3) Space Applications
(4) Future Trends

Offers of Papers are Invited. Please contact the Executive Secretary for further information.

Programmes and Registration forms will be available on request in due course.

IMAGE PROCESSING TECHNIQUES APPLIED TO ASTRONOMY AND SPACE RESEARCH

Date : **15-16 November 1979**

Venue : Science Research Council's Appleton Laboratory, Slough, Bucks. U.K.

Topics:
a) Astronomical Image Processing
b) Planetary Image Processing
c) Remote Sensing
d) Interactive Processing and System Design
e) Applications of Array Processors
f) Image Restoration

Offers of Papers to be presented at this Conference should be sent to the Executive Secretary, The British Interplanetary Society, 12 Bessborough Gardens, London, SW1V 2JJ, England.

Registration forms and programmes will be available later, on request.

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Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

CONTENTS

COVER

MARS MYSTERY. A strange feature discovered inside a Martian crater – the only such feature seen on the planet – is being studied by scientists on the NASA Viking mission. The highly reflective feature is in the bottom of a large crater about 93 km (58 miles) in diameter, located at 8 degrees south latitude, 335 west longitude. Although the formation has been nicknamed 'White Rock', its composition is unknown; because of its equatorial location it cannot be snow or ice. Estimates suggest it is 14 by 18 km (8.5 by 11 miles) across. Nancy Evans of the Jet Propulsion Laboratory has been named principal planetary geology investigator to study the 'White Rock' formation in an attempt to understand its history and composition. The pictures in this mosaic were taken on 1 September 1978 by a Viking Orbiter spacecraft from an altitude of 1,135 km (705 miles) above the Martian surface, and resolution in the Viking images is 144 metres (472 ft).

JPL, National Aeronautics and Space Administration

SPACEFLIGHT

A Publication of The British Interplanetary Society

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MILESTONES

November

12 After being kept under strict medical supervision at the Tyuratam/Leninsk space centre for 10 days, cosmonauts Vladimir Kovalyonok and Alexander Ivanchenkov are allowed to return to their homes in 'Star City' near Moscow. No unexpected changes in the cosmonauts' health were apparent. According to doctors, they had walked 1,400 paces in the park around Hotel Cosmonaut on 4 November only two days after their return.

13 NASA launches 3,150 kg High Energy Astronomy Observatory (HEAO) 2 by Centaur rocket from Kennedy Space Center, Florida, to study pulsars, quasars, exploding galaxies and 'black holes' (see 'Exploring the High-Energy Universe,' *Spaceflight*, July-August 1977, pp. 271-274).

14 Czechoslovakian satellite Magion is released from Intercosmos 18, launched 24 October, in orbit of 407 x 768 km x 83 deg. Satellites are designed to separate at precalculated rate to allow measurements of the magnetosphere and ionosphere at various distances up to 1,000 km.

15 Pioneer Venus 2, some 11.1 million kilometres from Venus at 6.37 p.m. PST, releases large entry probe for insertion into planet's atmosphere 9 December.

16 UK Science Research Council anticipates no further cuts in the budgets for astronomy, space research and nuclear physics in the next financial year. A new UK research programme being mapped out for the 1980's may include a spacecraft up to 12 ft (3.6 m) wide to be launched by the NASA Space Shuttle. The unmanned satellite – currently under study – would be capable of being retrieved, modified and re-used. Its specific role has yet to be decided.

16 Konstantin Feoktistov, Soviet spacecraft designer and cosmonaut (Voskhod 1), tells press conference at Moscow University that Salyut 6 space station is shortly to undergo a thorough check of its technical condition and working fitness: "The work of checking the station will take several months. The results of these studies will make it possible to determine its possible further use. The data obtained will also assist in developing plans for further contact with the station."

20 Pioneer Venus 2, some 9.3 million kilometres from Venus at 5.06 a.m. PST, releases three small entry probes for insertion into planet's atmosphere 9 December.

NEW PUBLICATIONS

As part of the Society's Development Programme, the B.I.S. Council has decided to introduce two important new issues of *JBIS* which should have wide appeal for all people interested in Astronautics. Mr. Mitchell, R. Sharpe, Historian at the Alabama Space and Rocket Center, has agreed to prepare an annual *Space History* issue. Mr. P.J. Conchie and Mr. G.J.N. Smith have agreed to initiate a series on *Science and Education* with two such issues envisaged this year. These publications are expected to appeal to schools and colleges, libraries and everyone interested in building up a personal file on the Foundations of Astronautics.

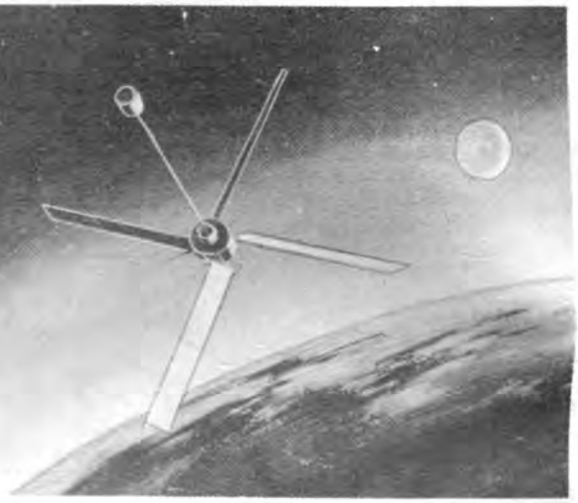
TRANSIT - THE FIRST NAVIGATIONAL SATELLITE SYSTEM

By Geoff Richards

Introduction

Navigation by satellite has escaped much of the publicity associated with other space applications such as communications and Earth resources observation, yet today many hundreds of ships regularly obtain navigation fixes of higher accuracy than can be obtained by any other method from observation of Earth-orbiting satellites. The satellites that provide this service form part of the Transit system and were originally developed for military use by the United States Navy. The shipboard radio receivers and computers that are needed to make use of the system are manufactured by a number of commercial electronics companies, including Redifon in the UK. The system is completed by a network of ground stations operated by the US Navy Astronautics Group.

The accuracy of a fix provided by the system is typically about 100 metres, though stationary receivers, on oil drilling platforms for example, can obtain 10 metre accuracy by making repeated measurements. In comparison, traditional sextant accuracy is about a kilometre and the various radio-navigation aids are even less accurate outside coastal waters. The main shortcoming of the Transit system is the fact that several hours may elapse between usable satellite passes and the average gap is around 90 minutes. As radio-navigation provides a continuous service the two methods are complementary and satellite fixes are used to give periodical corrections to the radio position



Transit navigational satellite *Ryan*

The Transit technique

Transit uses a radio-Doppler navigation method in which the ship's position is calculated from the observed change in the received frequency of the satellite's radio transmissions as the satellite passes across the sky. This technique grew out of observations of Sputnik 1 made in 1957 by scientists at the Applied Physics Laboratory (APL) of Johns Hopkins University in Maryland. The Doppler shift in received radio frequency from higher values for the approaching satellite to lower values after closest approach had of course been expected, but detailed analysis of the variation of frequency with time revealed the unexpected fact that the complete orbit of the satellite could be calculated from observation of a single pass and application of Newton's laws of orbital motion. Further analysis revealed that the converse was also true and this is the foundation of the Transit navigation technique: if a satellite's orbit is known then the Doppler curve from a single pass contains sufficient information for an observer to calculate his position on the surface of the Earth.

The accuracy of this method is limited by the frequency stability of the satellite's transmissions and the ability to predict the satellite's orbit between the time it is measured by a ground tracking station and the time the user observes the satellite. These factors require that the satellite carries an ultra-stable oscillator to control the transmitter frequency and that good mathematical models of the Earth's gravitational field and the effects of atmospheric drag and solar radiation pressure are available. A third potential source of error is the refraction of the satellite's transmissions by the ionosphere, but since this effect varies with frequency it can be measured and allowed for in the calculations by equipping the satellite with a transmitter operating on two different frequencies. The orbital elements and the time of day, which the user also requires to compute his position, are provided by data transmissions from the satellite itself. The satellite is equipped with a memory core which contains its position at two-minute intervals for several hours ahead and an electronic clock which is regulated by the ultra-stable oscillator. During each two-minute period the satellite transmits the appropriate orbital data and a time signal.

Satellite tracking is performed by four ground stations (three in the continental USA and one in Hawaii) which pass the information to two "injection stations" in California and Minnesota. These stations transmit commands to the satellite when it comes within range (typically at twelve-hour intervals) to update the orbital elements in the memory core and correct the clock. Use of powerful transmitters at the injection stations and an insensitive receiver on the satellite provides protection against stray signals from other sources affecting the satellite. The satellite transmits the update back to the injection station to check that it has received it correctly and there is time for several update transmissions on an injection pass if it has not. Several satellites are necessary to give the user a reasonable interval between satellite passes, and the operational Transit system involves a minimum of four satellites in polar orbits with orbital planes equally spaced in longitude. The satellites are placed in moderately high circular orbits (around 1100 km) to minimise atmospheric drag effects while providing a high Doppler shift. The orbital period and inclination should ideally be the same for all satellites to prevent the orbital planes drifting relative to each other and thus opening gaps in the satellite coverage of the Earth, though if the inclination is around 90° the effect of orbital period is small.

Transit research and development

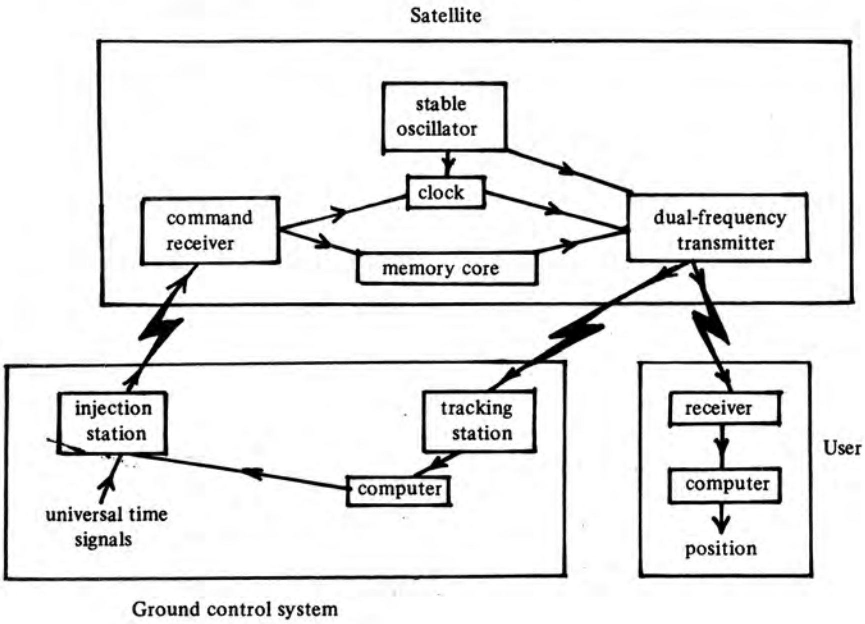
The Transit system was developed to meet a requirement by the US Navy for an accurate navigation system for its Polaris submarines, as the accuracy of the missiles was limited by the uncertainty in the position of the submarine at the moment of launch. At the time (1958) the APL technique was the only one that promised to provide the required accuracy and so a contract for the development of a navigation satellite was placed with the laboratory in December of that year. Although no suitable ultra-stable oscillator was available "off the shelf," the first satellite was designed and built in only seven months. Unfortunately this satellite was lost when the third stage of its launch vehicle failed to ignite, but success came a few months later

with the launch of a back-up satellite on a Thor-AbleStar vehicle from Cape Canaveral. This launch was incidentally the first to involve the re-start of a rocket engine in space. The satellite, Transit 1B, was a sphere with a diameter of 0.91 metres and a mass of 121 kg, most of the latter being for chemical batteries. A few solar cells augmented one block of batteries and the satellite was stabilised by a system of magnets interacting with the Earth's magnetic field. Infra-red Earth sensors monitored the de-spin of the satellite by the magnets and a "yo-yo" weight release system. The payload consisted of two stable oscillators and two dual-frequency transmitters operating at 162 and 216 MHz and 54 and 324 MHz. The antennae were spiral slot types in the surface of the sphere. Although the orbit was lower than planned the satellite was still able to demonstrate the successful operation of ultra-stable oscillators in the space environment during the three months the batteries provided power.

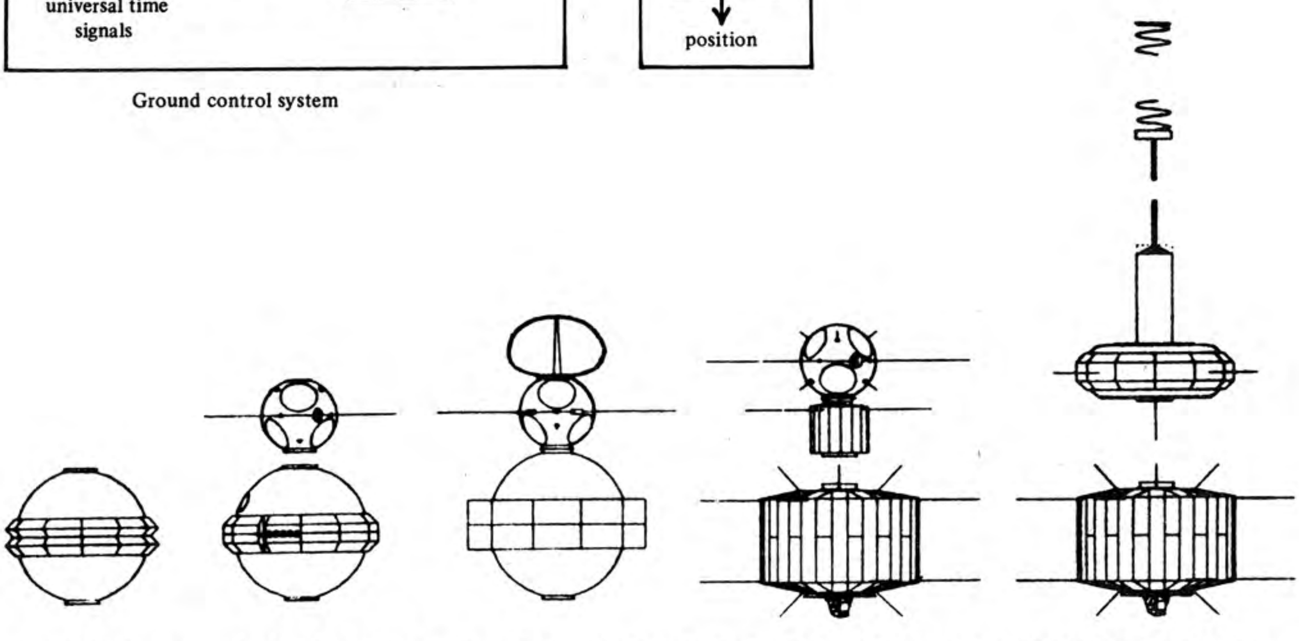
Transit 2A, which was successfully placed in orbit by the next launch, was the first flight-test of the electronic clock. It also had more solar cells and fewer batteries than its predecessor and the weight saved allowed a second satellite to be carried on the same launch vehicle. This was the first successful dual launch and set a precedent for the programme. Most subsequent Thor-AbleStar launches carried at least two payloads and the final launch of the vehicle in August 1965 carried no fewer than seven. Transit 2A contained in addition to the navigation equipment a Canadian experiment to measure cosmic radio noise, making it the first international satellite.

Transit 3A was lost in a launch mishap which caused an international incident of a different type when debris from the rocket fell on Cuba and killed a cow. The replacement, Transit 3B, also suffered launch problems which left it in a low orbit and still attached to the AbleStar stage and a secondary payload. However, this satellite did demonstrate the operation of a small magnetic memory system in the month before it decayed in the atmosphere and also performed the first flight-test of a "Secor" transponder for the US Army's geodetic measurement programme.

The next two satellites, Transits 4A and 4B, were cylindrical rather than spherical and tested two alternate designs

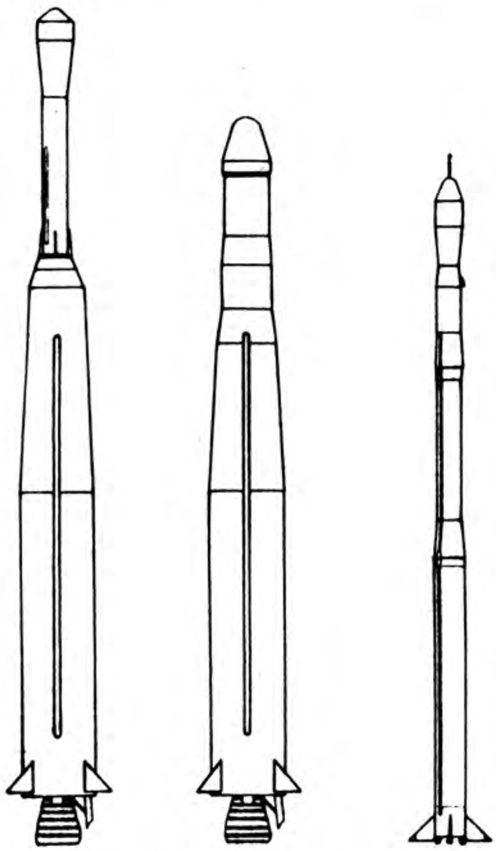


The basic elements of the Transit radio-Doppler navigation system.



Transit development payloads and secondary satellites. *Left to right,* Transit 1B, Transit 2A and Solrad 1, Transit 3B/Lofti 1, Transit 4A and Solrad 3/Injun 1, Transit 4B and Traac.

Drawing by the author



Launch vehicles used for Transit satellites, *left to right*, Thor-Able 2, Thor-AbleStar and Scout.

for the memory core. Improved oscillators were also carried and the 162/216 MHz transmitter was dropped in favour of one working at 150 and 400 MHz, the frequencies which were to be used on the operational satellites. These two satellites were the first to use nuclear power sources in space. The sources were SNAP-3B radio-isotope thermoelectric generators (RTGs) and they augmented power systems that again had more solar cells than previous flights. The secondary payload launched with Transit 4B was a doorknob -shaped satellite called Traac (Transit research and attitude control) which was intended to test a gravity-gradient attitude control system which was under development for the operational satellites. It was only partially successful in this, however, as its 20 m stabilisation boom failed to deploy properly. In theory the satellite should have "hung" like a plumb-line from the weight on the end of the boom, thus keeping one side of the satellite pointing always down to the Earth so that a directional antenna could be used. In the event Traac only achieved roughly the correct attitude after several months in orbit. Transit 4A set a record by operating for more than ten years in space, but Transit 4B and Traac had their lives cut short in July 1962 when their solar cells were damaged by radiation from the "Starfish" high altitude nuclear explosion. These were the final research and development launches in the programme, though Transit technology was used in the Anna, Beacon Explorer and Geos series of geodetic research satellites and modified Transit satellites have carried a variety of scientific payloads for the US Department of Defense.

In parallel with the satellite development a programme was conducted to obtain the necessary high-accuracy model of the Earth's gravitational field, an effort which is still continuing today. A network of 13 tracking stations (TRANET) was established around the world to give practically continuous coverage of a satellite in orbit. Transit and other suitable satellites are tracked by this network and the data are sent to APL for analysis. The computing task involved in reducing this data and calculating the model of the Earth's field (as a series of several hundred spherical harmonic terms) is a massive one, but it has paid off in a series of progressively more accurate models that have reduced the errors in predicting the orbit to less than ten metres.

The only significant change from the Transit technique as originally envisaged has been in the receiver for the users' system. It was found that instead of measuring the Doppler shift directly the same accuracy could be obtained by taking the integral of the shift over the two-minute period used to transmit a complete set of time and orbit data. This integral can be obtained by fitting a simple counting circuit in the receiver to count the cycles in the received signal, and this results in considerable cost savings compared with a receiver capable of direct frequency measurement to the required accuracy.

The Operational Phase

The operational satellites carry only one dual-frequency transmitter. At around 60 kg they are much lighter than the development payloads and they can therefore be launched by the smaller and cheaper Scout vehicle. The body of an operational satellite is an octagonal prism 0.30 m long and 0.46 m wide. A gravity-gradient stabilisation boom extends 30 m from the top of the prism and carries an end-mass of around 1.5 kg. On the early satellites this was further extended by a damping spring between the boom and the mass to reduce oscillations, and the end-mass carried a self-contained solar-powered flashing light beacon. Solar cells on the prism gave some indication of spring position by detecting the light flashes. Later satellites have relied on magnetic rods for damping. Four rectangular solar-cell panels extend from alternate sides of the prism to give a cruciform shape with a span of about 3.5 m. Command and telemetry antennae are mounted on the tips of two of the panels and the main transmitting antenna is on the underside of the prism so that it is directed towards Earth. Total radiated power is a respectable 1.5 watts so the user receivers do not require large antennae. The 5 MHz oscillators are as stable as laboratory crystal clocks, with a drift rate of less than five parts in a hundred thousand million during a twenty-minute pass. This is an order of magnitude better than the best of the two oscillators on Transit 1B and is achieved with the aid of a thermal control system which regulates the crystal temperature to a thousandth of a degree K. The memory has a capacity of six thousand numbers, sufficient to store orbital data for 16 hours ahead. The yo-yo weights and the magnetic attitude control system are retained for de-spin and initial stabilisation prior to boom deployment.

The first prototype operational satellite, Transit 5A1, was launched in December 1962 from Point Arguello (now part of the Western Test Range) in California, but its command receiver failed during launch so that the flight was a failure. The following March a security classification was placed on the entire programme, but sufficient information has been released in later years to piece together the story. The second Transit 5A flight also ended in failure when the last stage of the Scout launch vehicle malfunctioned, but Transit 5A3 successfully achieved orbit and became the first gravity-gradient-stabilised satellite. It was not an operational success due to telemetry system problems, but it nevertheless marked a major step forward. The 5B series differed from the standard operational configuration as they were powered entirely by nuclear energy, another first

Operational Transit satellites. *Left to right,* Transit 5A, Transit 5B (with SNAP-9A nuclear generator) and NNS.

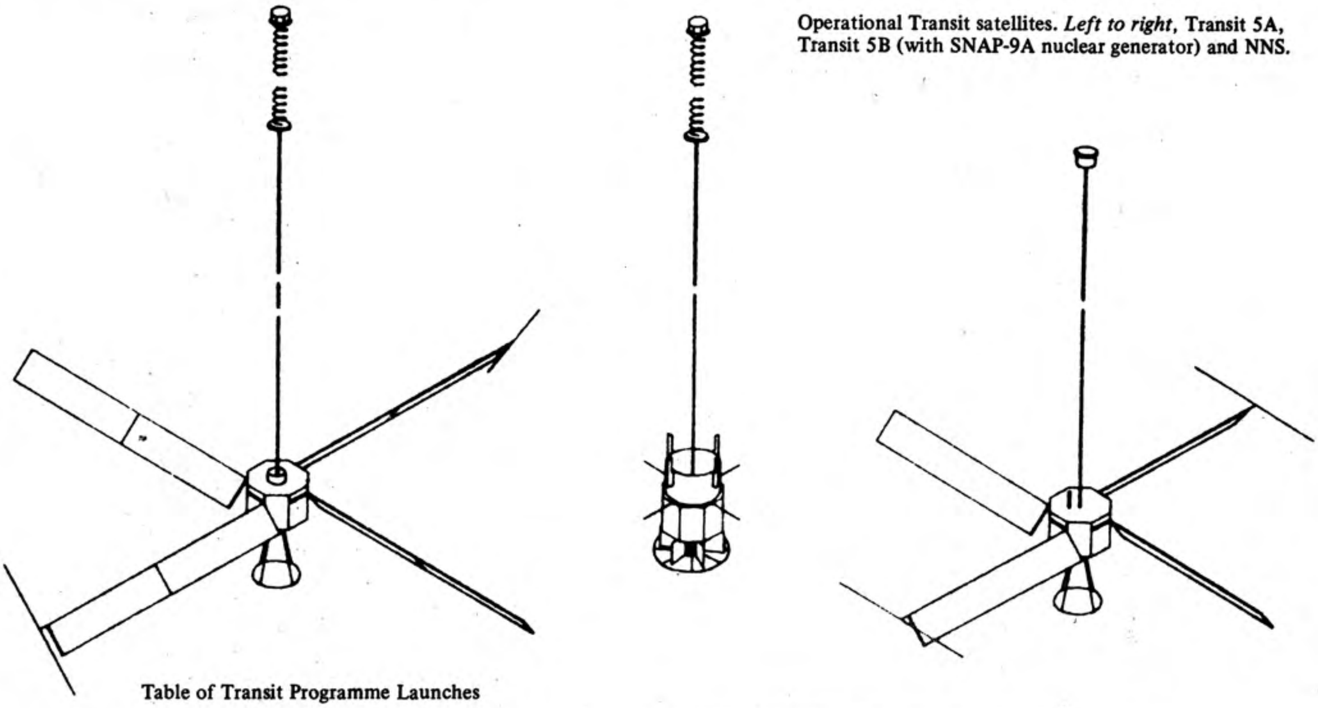
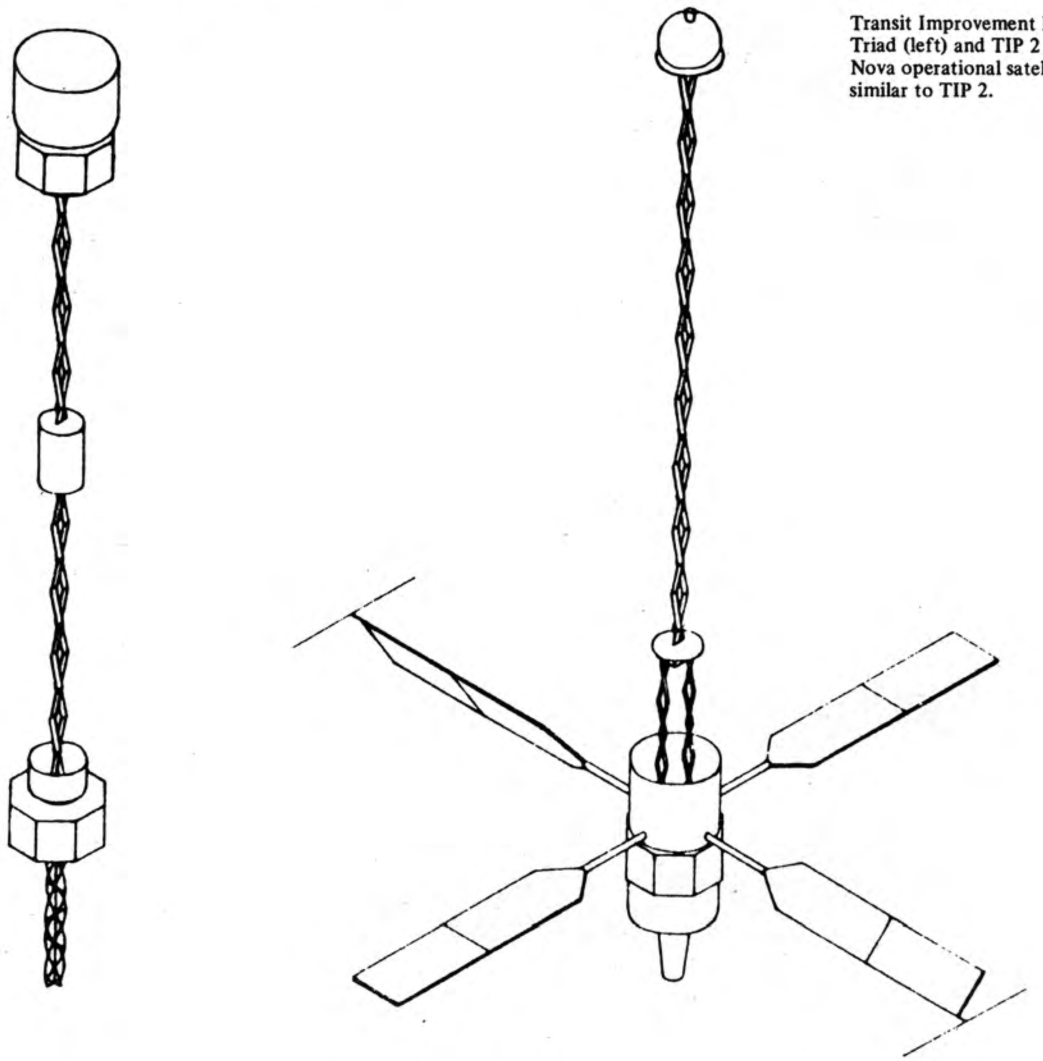


Table of Transit Programme Launches

Name	Date	Launch data Vehicle	Site	Perigee (km)	Apogee (km)	Period (min)	Incl. (deg)
Transit 1A	17 Sep 1959	Thor-Able 2	ETR		failed to orbit		
Transit 1B	13 Apr 1960	Thor-AbleStar	ETR	373	748	95.81	51.28
Transit 2A	22 Jun 1960	Thor-AbleStar	ETR	628	1047	101.66	66.69
Transit 3A	30 Nov 1960	Thor-AbleStar	ETR		failed to orbit		
Transit 3B	22 Feb 1961	Thor-AbleStar	ETR	167	1002	96.22	28.38
Transit 4A	29 Jun 1961	Thor-AbleStar	ETR	881	998	103.82	66.81
Transit 4B	15 Nov 1961	Thor-AbleStar	ETR	956	1104	105.63	32.43
Traac				941	1119	105.64	32.43
Transit 5A1	19 Dec 1962	Scout	WTR	698	725	99.12	90.62
Transit 5A2	6 Apr 1963	Scout	WTR		failed to orbit		
Transit 5A3	16 Jun 1963	Scout	WTR	724	757	99.67	89.97
Transit 5BN1	28 Sep 1963	Thor-AbleStar	WTR	1075	1127	107.42	89.90
Transit 5BN2	5 Dec 1963	Thor-AbleStar	WTR	1067	1112	107.18	89.98
Transit 5BN3	22 Apr 1964	Thor-AbleStar	WTR		failed to orbit		
Transit 5C	4 Jun 1964	Scout	WTR	854	956	103.12	90.42
1964-63B	6 Oct 1964	Thor-AbleStar	WTR	1055	1085	106.65	89.92
1964-83D	13 Dec 1964	Thor-AbleStar	WTR	1025	1084	106.33	89.86
1965-17A	11 Mar 1965	Thor-AbleStar	WTR	211	890	95.19	89.97
1965-48A	24 Jun 1965	Thor-AbleStar	WTR	1024	1144	106.92	90.00
1965-65F	13 Aug 1965	Thor-AbleStar	WTR	1089	1194	108.19	90.01
1965-109A	22 Dec 1965	Scout	WTR	909	1086	105.09	89.11
1966-05A	28 Jan 1966	Scout	WTR	861	1217	105.99	89.78
1966-24A	26 Mar 1966	Scout	WTR	891	1128	105.37	89.73
1966-41A	19 May 1966	Scout	WTR	863	980	103.48	90.00
NNS 10	18 Aug 1966	Scout	WTR	1056	1101	106.85	88.86
NNS 12	14 Apr 1967	Scout	WTR	1053	1083	106.60	90.23
NNS 13	18 May 1967	Scout	WTR	1074	1105	107.04	89.57
NNS 14	25 Sep 1967	Scout	WTR	1041	1116	106.81	89.28
NNS 18	2 Mar 1968	Scout	WTR	1035	1139	107.00	89.99
NNS 19	27 Aug 1970	Scout	WTR	955	1221	107.04	90.02
Triad (TIP 1)	2 Sep 1972	Scout	WTR	716	863	100.68	90.14
NNS 20	30 Oct 1973	Scout	WTR	895	1149	105.62	90.18
TIP 2	12 Oct 1975	Scout	WTR	362	705	95.34	90.74
TIP 3	1 Sep 1976	Scout	WTR	348	789	96.02	90.31
Transat (NNS 21?)	28 Oct 1977	Scout	WTR	1069	1107	107.03	89.92



Transit Improvement Program satellites: Triad (left) and TIP 2 (right). The new Nova operational satellites will be similar to TIP 2.

for the programme. Each satellite carried a SNAP-9A RTG instead of the four solar panels, and the greater mass (73 kg) necessitated a temporary return to the Thor-AbleStar launch vehicle.

The first of this series, Transit 5BN1, seemed initially to be a success, but outgassing as the damper spring deployed caused the satellite to tumble and when it eventually re-stabilised it did so upside-down so that the antenna pointed away from the Earth. Transit 5BN2 carried a more powerful magnetic control system to counteract the outgassing torques and it recovered from an inverted position to become the first complete success in the operational programme. It was declared operational in January 1964 and the Transit system has provided a continuous service from that date to the present day. Transit 5BN3 was lost in a launch failure that again caused an international incident when it was disclosed that a kilogram of radioactive plutonium had been dispersed through the upper atmosphere over most of the southern hemisphere, though as the initial re-entry was over the ocean there was not the same outcry that greeted Cosmos 954. The next launch, Transit 5C, reverted to solar power and the Scout launch vehicle. The satellite was placed in an orbital plane at right angles to that of Transit 5BN2 and the system became fully operational in July 1964.

Up to this time the reliability of the Scout vehicle had not been impressive. The Navy had lost two payloads (the second was a small research satellite) in five launches and other agencies had had similar experiences. The Navy therefore decided to use the Thor-AbleStar until Scout reliability improved. A second consideration in coming to this decision was the better guidance accuracy of the AbleStar, which meant much smaller errors in orbital injection and smaller orbital plane drift rates, so fewer gaps in orbital coverage developed and users could obtain navigation fixes at more regular intervals. Following this decision Scout reliability in fact showed a rapid improvement and Scouts have launched 18 Navy satellites since 1965 without loss.

Information on the next nine launches is sparse. At some time during this period the name "Transit" for the satellites was discouraged and a variety of alternatives have since been used, such as Navy Navigation Satellite (NNS), NavSat and Oscar. Some of the nine were built in-house by the Navy Avionics Facility rather than by APL. The first of them (1964-63B) apparently failed to separate from a secondary payload and the third (1965-17A) was left in low orbit by a launch vehicle fault, but the next four satellites formed the first complete network with orbital planes at 45° intervals. Apart from the two failures there were three other Thor-Able Star launches and four Scout launches in this series, and all seven appear to have been generally successful except for the fact that the achieved operational lifetimes were only about a year instead of the planned five years; hence the continuing high launch rate during this

period. The main fault was found to be in the solar panels, where electrical joints were coming apart under the thermal stresses that occurred as the satellites passed in and out of the Earth's shadow on each orbit. The fault was eventually cured on NNS 10, launched in August 1966, though this satellite was to cause a different problem in the early 1970's when it switched itself on after it had been de-activated and its transmissions occasionally interfered with those of later satellites. The last three APL satellites (NNS 12, 13 and 14) were launched in 1967 and have achieved operational lifetimes of a decade in orbit.

In July 1967 Vice President Humphrey announced that the system was open to general civilian use, though in fact a number of civilian oceanographic research ships had been equipped with receivers during the previous year. Initial response to the announcement was lukewarm as the shipboard equipment was very costly. However the liner *Queen Elizabeth II* was a distinguished early customer and in recent years costs have come down as production rates for receivers increased so that there are now over 2,000 civilian users, outnumbering naval users by four to one. For many civilian applications there is no need for the extra accuracy that is given by applying an ionospheric refraction correction and cheaper single-frequency receivers are adequate, but for some applications, particularly oil-rigs, there is the same need for high accuracy as the Navy's.

In 1966 and 1967 the Navy ordered two batches of six replacement satellites each from RCA. The first of these, NNS 18, was launched in March 1968 to complete a longer-lasting four-satellite operational network than that of 1965-1966. Three more have been launched in the last 10 years to replace failed satellites or fill any 75° gaps that develop as the orbital planes drift. One of these launches was of NNS 20 on 30 October 1973, within two days of an attitude control problem developing on NNS 18. The sight of this launch provided an unexpected bonus for a party of British Interplanetary Society members who were visiting Vandenberg Air Force Base at the time.

Transit Improvement Programme

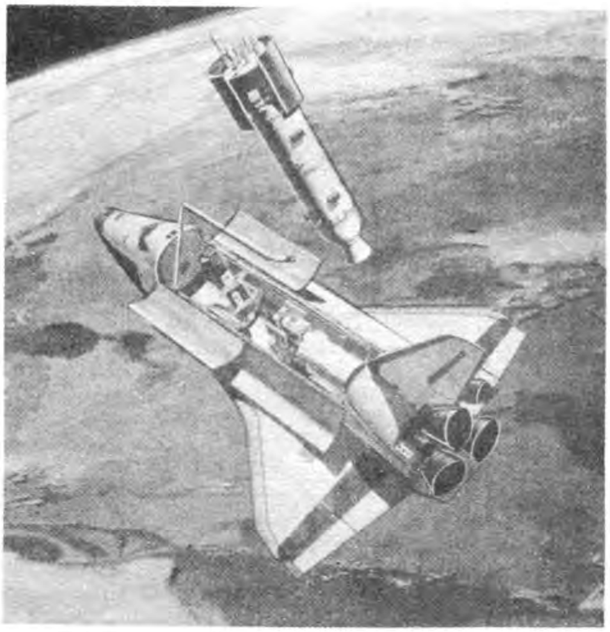
Although the operational system has been in use for 14 years the Navy has continually sought means to improve it, such as the implementation of better gravitational field models. In recent years this effort has also included a number of experimental APL satellites to test various systems for future operational use under the name of the Transit Improvement Program (TIP). The first of these, called Triad (both from its shape and as an acronym of Transit Improved and Discos), was launched in September 1972. It was a 7.3 m long dumb-bell in shape, with a mass of 94 kg, and its payload included a new type of RTG as part of the power system. The most significant experiment, however, was the Discos (Disturbance Compensation System) which sensed the atmospheric drag and radiation pressure on the satellite and controlled firings of six cold-gas jets to compensate. The Discos was mounted in the central body of the "triad" and its sensor was a small sphere in a hollow container at the centre of gravity of the satellite. This followed its own orbit shielded from the surface forces acting on the main satellite. Its position inside the container was measured electrically and the main satellite thus controlled to follow the same orbit as the sphere. The system operated for a year on 1.4 kg of Freon gas for the jets and permitted accurate predictions of the orbit for several weeks in advance. When this system is adopted for operational satellites the orbital elements in the memory core could be updated every week instead of every twelve hours with a big saving in ground support costs.

The second TIP satellite was launched in October 1975. It was solar powered and superficially similar to the standard operational satellites, though the mass was much higher at 166 kg. The satellite carried a simplified Discos, which gave only single-axis control along the direction of the orbit, and a hydrazine rocket for large orbit adjustments. The electronics were hardened against radiation damage and featured a computer instead of the hard-wired memory core and a system for correcting frequency errors in the clock by ground command. Unfortunately the solar panels failed to deploy and a replacement launched a year later suffered the same fate. However, some systems tests were possible and this basic configuration has been chosen for future replacement satellites. A contract was placed with RCA early this year for three 135 kg satellites of this type to be called "Nova."

The Future

Transit is a mature operational programme. There are currently six satellites in use and another was ready for launch in 1978 if required. The first of the improved Nova type is scheduled for launch in 1979. However, the new NavStar navigation satellites of the joint services Global Positioning System are now being flight-tested and will eventually provide a continuous high-accuracy navigation service not only for shipping but also for aircraft, ground troops, other spacecraft and general civilian applications.

In consequence earlier plans to expand the Transit satellite segment to provide continuous coverage have been abandoned. The Navy will certainly continue to operate the Transit system until NavStar is fully operational in the mid-1980's, but whether it will continue beyond that time for the benefit of civilian users who find the present much cheaper system adequate for their needs is uncertain. It depends on how much funding the US government will be prepared to provide for what will become purely a public service system. Whatever happens, the Transit system will have provided a unique service for two decades and will stand as a major milestone in the development both of marine navigation and of the exploitation of space.



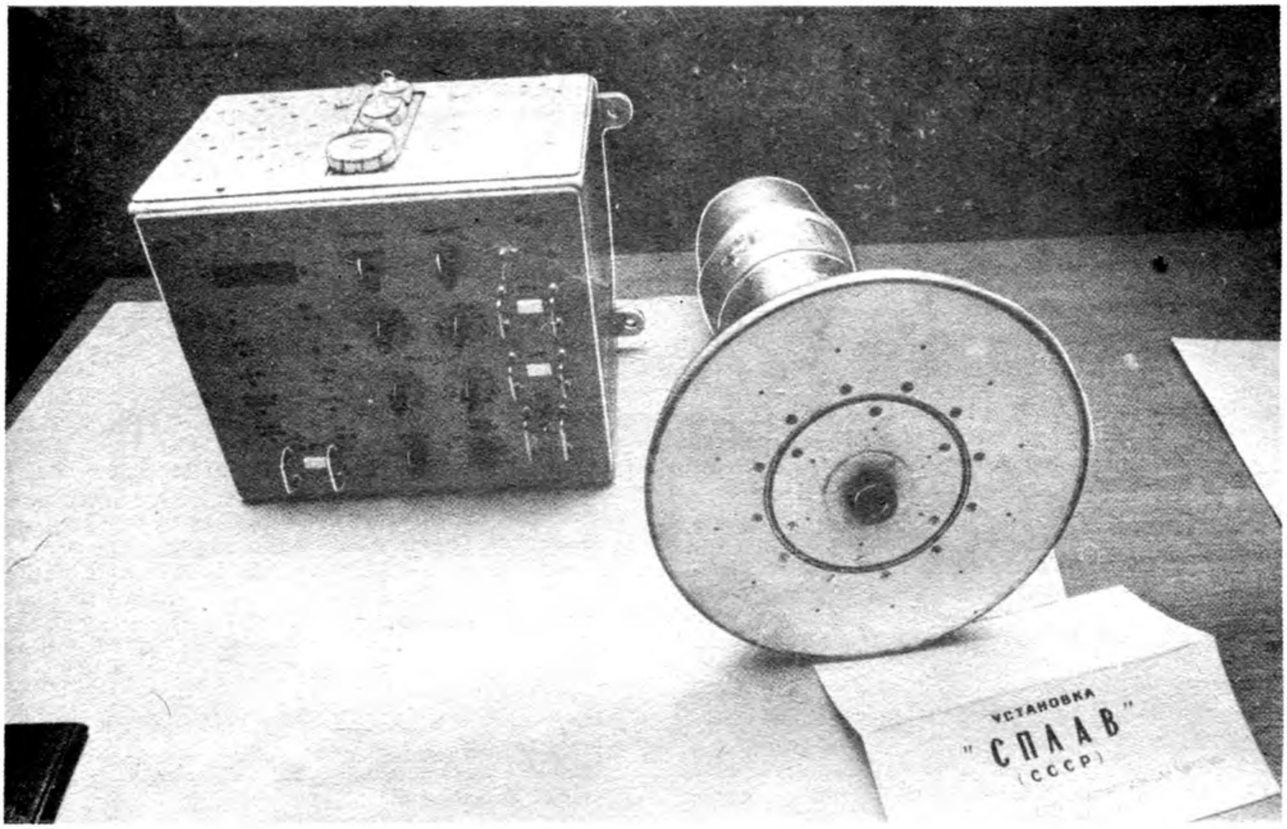
NAVSTAR. One of the Space Shuttle's most valuable attributes will be its ability to transport multiple payloads. Being released here into low Earth orbit are two Navstar global positioning system satellites with attached propulsion stages, while an Advanced Radio Astronomy Explorer/Interim Upper Stage combination in the aft end of the cargo bay awaits deployment.

Rockwell International

THE SPLAV 01 FURNACE

By Wilhelm Hempel*

Standard Equipment on Manned Space Flights



The Splav space furnace on display at the Flight Control Center in Kalinin in September 1978.

Panorama DDR/Zentralbild

Introduction

For some time now Soviet cosmonauts have performed "technological experiments" onboard Soyuz and Salyut spacecraft. Now such experiments are also on the programme of cosmonauts from other socialist countries. They are performed to produce new types of high-quality materials under the specific conditions of outer space.

These conditions include: the lowest temperatures close to absolute zero which can be reached on the shadow side of an orbital station; the most ideal vacuum existing in orbit, and – probably most important – near-weightless conditions achieveable in a spacecraft flying freely in space. The latter has two main benefits: firstly, it permits the breeding of very regular crystals. Under terrestrial conditions, crystal growth is influenced by gravitation whether they originate in a solution or a melt. That is why their shape frequently differs from what is expected, for the expectations are based on the material's atomic properties. This is quite important, for as they reach ideal conditions, as described in textbooks, they undergo considerable property changes particularly in tensile strength. Perfect tiny crystals – so-called "whiskers," hair-shaped one-millimetre carbon structures, for example – are a hundred times stronger than normal graphite. Therefore, they can form a valuable and extremely tough composite structural material and are used, for example, in the protective coating of spacecraft heat shields.

Advantages of Space Processing

Some metallurgical experiments were performed with success on earlier space flights. The soldering of steel pipes and copper-silver alloys produced crystals which had a diametre of 2.5 cm, some ten times bigger than their terrestrial counterparts. Whiskers were drawn from semiconductor materials the roughness of which was less than a hundred thousandth of a millimetre.

Secondly, under weightless conditions, there are no problems in segregating specifically light and heavy substances whereas on Earth it is often impossible to produce alloys using such substances. This also applies to extreme cases such as the regular permeation with gases of solid substances, including metals, glass and pieces of pottery. In space, for example, it should be possible for helium gas to penetrate steel to such an extent that it becomes a sponge-like material as light as cork but still as hard as normal steel.

Space Factory

It is optimistic of course to talk of "production in space" at the present time. The costs of transporting materials to and from the space stations are much too high for large quantity production of such materials. But if we think of the rare and very pure semiconductor materials which cost up to half a million marks per kilogramme, the exploitation of space for industrial purposes is economically feasible.

The methods developed by Soviet space planners are almost perfect. The standard equipment of Salyut spacecraft now includes two furnaces in which materials can be melted

* *Presidium Member, GDR Astronautical Society.*

One of them can reach a temperature of 1000˘C. The other furnace, called Splav 1 (Alloy), is a high-temperature furnace weighing 23 kg and consuming 300 watts. One side of it is connected by a small air lock which can be exposed to space so that melting takes place in a vacuum and surplus heat is conducted away from the work area and radiated into space. Molybdenum reflectors inside the furnace ensure that the heat always concentrates on the sample. This ensures that the temperature of the furnace wall does not exceed 40°C and does not place an undue burden on the station's air conditioning system.

Yuri Romanenko and Georgi Grechko were the first to test onboard Salyut 6 samples of copper and indium, aluminium, magnesium and indium-antimonide and later of aluminium and tungsten which were brought back to Earth for detailed investigation. The next one to perform experiments with the "Splav" furnace was Captain Vladimir Remek of Czechoslovakia who in the joint "Morava" experiment produced electro-optical materials, including twin crystals of silver-lead chloride and copper-lead chloride.

After a three-month break, Vladimir Kovalyonok and Alexander Ivanchenkov switched on the furnace again, and the next cosmonaut to use it for experiments was Major Miroslaw Hermaszewski of Poland. Researchers at the Warsaw Institute of Physics have been working for more than ten years on mercury-cadmium-telluride which is an exotic semi-conductor substance. They asked the first Polish cosmonaut to supply a sample of this material made under the conditions of space flight.

Major Hermaszewski took a quartz ampoule containing a pre-melted crystal blank. In the "Splav" furnace one-third of it was liquefied once again and cooled down. The cooling was controlled by a computer and performed according to a detailed schedule. Thus the Warsaw physicists now have two samples which were produced under completely different conditions. The 'Syrena' experiment is of great practical importance, for mercury-cadmium-telluride is a semiconductor material which is used to measure the quality and quantity of infrared radiation.

SOCIETY NEWS

AN AMERICAN VIEW OF SETI

On 17 October 1978 members of the Society heard a fascinating lecture on the Search for Extra-terrestrial Intelligence (SETI) by Dr. John Billingham who is Chief of the SETI Program Team of the National Aeronautics and Space Administration.

Dr. Billingham stressed the *Search* for extra-terrestrial intelligence as opposed to CETI (Communications with Extra-terrestrial Intelligence). There was absolutely no intention to attempt communications should a signal be received from an extra-terrestrial civilisation.

Dr. Billingham began by outlining how the present NASA programme came into being. It started by reviewing the work that had been done to date – examining the basic arguments for possible flaws and amending to suit the latest thoughts. The review concluded that the basic concepts were sound and that a low noise universal radio frequency band lying between 1000 MHz and 100,000 MHz was the best area to explore. In particular, the "water hole" as originally proposed by Dr. Bernard Oliver (1420 MHz to 1660 MHz) formed the best starting point.

Accordingly, several simple modular experiments had been devised which would fit into an overall low cost programme. The ongoing NASA SETI programme had, to date, confined itself largely to paperwork studies but during the first quarter of 1979, a week of star searching would be carried out. This experiment would scan 250 stars within 100 light years from the Sun. All of these candidates were in the G - K dwarf class (i.e., solar type) of star. Allowing for the duty cycle of the telescope scanning angle and the rotation of the Earth, approximately 10 minutes of time would be allocated to each star.

The receiver being constructed for the experiment will be swept over the band of 1300 MHz to 1700 MHz with special emphasis on 1420-1660 MHz. The receiver has a bandwidth of 4 MHz which is then multiplexed into 10^6 channels, each channel being 4 Hz wide. The eventual aim is for each channel to be scanned by a pattern analyzer which will look for recognizably correlated aspects of the channel content. The analyzer at present is in the study phase, for there are various ways in which the storage of pattern data may be accomplished. Billingham considered that integrated circuits (silicon "chips") were probably the best technical and most cost effective solution. It is expected that the pattern analyzer will be funded and constructed during the coming financial year. Meanwhile the data will be stored on tape for future detailed analysis.

The initial experiment described by Billingham will be done between mid Jan 1979 and mid Feb 1979, and will use one of the most sensitive antennae available – the 1000 ft (300 metre) dish at Arecibo. This would be the first stage of a long term experiment. The remaining stages would be carried out on Earth using larger and larger antennae – the VLA installation in Mexico promises to be the largest available in North America. Although smaller than 'Cyclops', the final version of VLA consists of some 30 antennae, each of 100 metres diameter. Beyond that size, a space installation would probably be cheaper than one sited on Earth.

Billingham was emphatic that Moon-based items would probably not be cost-competitive with either Earth or space items. The improvements in sensitivity would eventually be traded off with larger numbers of channels and a larger bandwidth. The final aim would be 10^8-10^9 channels concentrated in a bandwidth of say, 100 MHz, ultimately exploring all of the available band of 1000 to 100,000 MHz.

In reply to questioning Dr. Billingham stated that this work would continue at the present low level, ready to be raised in effort as and when funding allowed. The cancellation in funding for the present year *only applied to the present year* and would not stop the ongoing effort, he said.

During the course of the lecture he showed records obtained from examination of a particular star. Initially the results looked promising, a 1420 MHz signal which was fairly narrow. On closer examination there were "harsh" sidelobes and the bandwidth was far too wide – and it was probably a man-made signal.

Ultimately, the programme was envisaged as being international. We await the initial results of the Arecibo soundings with interest!

As a final flourish to an excellent evening, Dr. Peter Van de Kamp (late of Swarthmore College, Sproul, Pennsylvania) gave a short and up to date account of research results on

possible companions to Barnard's Star. Some authorities had cast doubts on the earlier results reported in 1963 (Van de Kamp's single planet solution) and later work in 1969 (Van de Kamp's 2 planet solution).

Since the doubts had some valid support, Van de Kamp discarded all data prior to 1950. At this time the telescope underwent a refit which considerably improved the stability of the objective lens (an aluminium mounting cell was replaced by a cast iron item). Data acquired since that time has been carefully measured and rechecked and shows that Barnard's Star is *still* showing signs of being perturbed by at least *one* companion. Significantly, the orbital period is different to the earlier solution. Principal data are as follows:

Period - 11.5 to 12 years (insufficient data to be more precise).

Mass $\approx$ 1.0 x Jupiter

There are signs of a further perturbation which gives *tentative* data as follows:

Period - Approximately 20 years (insufficient data to be more precise).

Mass $\approx$ 0.4 x Jupiter

Those who are aware of Van de Kamp's earlier solutions will note the absence of a 26 year period in the above data. This is now regarded as spurious and is due to the telescope problems outlined earlier. Van de Kamp expects to improve these results very slightly by the end of the year (1978), but does not expect any major departure from the above. He tended to regard the 3 and 5 planet solutions as unlikely and pointed out that over treating the material tended to squeeze out "information" that was probably spurious.

Van de Kamp then talked about astrometric perturbation of *Epsilon Eridani* as measured by the Swarthmore College Observatory. The perturbation is real and calculation yields a mass about 8 x that of Jupiter with a period of 26 years. Recent refinement of this result had tended to give a reduced amplitude but no change in orbital period. Van de Kamp emphasised that this was normal, and expected to publish these results (which should give a slightly smaller mass) very shortly.

Dr. Van de Kamp wound up the evening by saying that, based on his earlier work which involved initially unseen companions which were formally resolved by large telescopes, he was satisfied that the perturbations *were* real. Further analysis of post 1950 plates had shown that other nearby red dwarfs (the "red proletariat" as he called them) were showing signs of perturbation. Results on this new material would be published in due course. – A.T. Lawton.

SOCIETY FILM SHOW

Fifty members and guests braved the elements, and a rail strike too, to attend the Society's film show at University College London, on 15 November 1978.

Four films were billed, but the audience gained an extra bonus with the arrival of a new film which was also screened, for the first time.

It is often said that when two Englishmen meet they invariably talk about the weather. If so, the first film called "The Weather Watchers: Understanding the Weather" would have been particularly appropriate.

The science of weather forecasting began to develop, together with a rough measure of prediction, in the 19th century. Today, using computers and advanced sensors, a wide range of Nature's secrets are being probed. Since 1960, when the first American weather satellite was launched, advanced weather watching capabilities have been realised. Geosynchronous satellites, from the mid-'60's, made it possible to maintain a constant vigil, while improved resolution and infrared sensors added to that capability. Soon there will be five of such satellites in orbit, producing a constant updated stream of weather readouts.

Looking for weather cells, together with a special watch for the growth of hurricanes and severe storms,were illustrated with spectacular speeded-up shots of tornado development. Equally fascinating were shots showing cloud movements simultaneously over one half of the Earth's disc.

"Remote Possbilities" – with the added subtitle of "A Satellite for all Seasons" was off to a rapid start with several pictures occupying the screen as insets at the same time.

The apparently serene vista of the Earth, seen from space, masks its massive population and the rapid exhaustion of its natural resources.

Landsat opened a new era in environmental studies and Earth resources management. Different areas of the Earth's surface reflect different amounts of light: the multi-spectral scanners reflect this light at its different wavelengths to the sensors inside the satellite, the spectral bands,thus creating Landsat's unique images.

Landsat transmits signals used to form pictures. Each point on the picture, called a pixel, covers an area of 1.8 acres . The pixels are classified into 48 numbers, depending on their degree of brightness – the bright areas getting a high number and dull areas a low number. The numerical information thus received is stored on tape and later used to make images on film. (There are over 7 million pixels on each complete Landsat picture). The difference between the pixels can be emphasised by using coloured filters. The colours are not true, e.g. vegetation appears red, but shots in the film indicated how digital computers could be used to print out and emphasise such features as sedimentation at a river mouth.

Landsat images contain a wealth of material, some of it obvious but some very subtle. One such example featured the remote sensing of a swamp, otherwise almost impossible to achieve, but checked out by a ground truth expedition. Among the surprises was a Landsat identification of what later turned out to be a beautiful cedar forest.

Midway in the programme came "Earthspace" – concerned with the Earth's weather and longer term climatic changes. The film included many shots of the ever-changing aurora and quite a detailed discussion of the Earth's radiation belts – all of which served to show, all too clearly, that there is still much to learn, with the use of the Shuttle foreshadowed as a really new means for a much more massive investigation.

Amongst incidental information given was that the Sun is under continuous watch, with a particular look-out kept for impending flares.

"If One Today, Two Tomorrow" was a film which posed a number of questions such as "what will be the tools of tomorrow's education, food production, etc. – with ever-growing human needs and limited resources. Many of these problems can be helped by better communication.

The developments of communications technology over the last century has drastically accelerated the pace of human development, with satellites now playing a major role. ATS 6, placed in orbit in 1974, used with simple inexpensive antennae, was used for transmitting medical information in Alaska: in 1975 it was moved eastwards to be used for a one-year educational programme in India on agriculture, social and cultural matters. The ground antennae depicted were made up largely of chicken wire and cost no more than £120 each.

As an interesting sidelight, it was reported that the Indian villagers much preferred educational programmes to enter-

tainment. "Their time was far too valuable" – it was said.

Educational programmes of this type were featured in a number of other countries, Pakistan and El Salvador being shown as examples.

The only outward-looking film on this occasion was "Mercury – Exploration of a Planet," which concerned the flight of Mariner 10. This spacecraft undertook a particularly valuable flight, not least because it took high-resolution photographs of Venus in the ultra-violet on the way and so made possible the first mosaic showing the entire planet – these indicating quite clearly the very bright Southern polar cap, appearing almost as though it lay in the centre of a vortex.

Particularly fascinating were the time-lapse pictures showing the rotation of Venus, taken in the ultra-violet, and it was most intriguing to realise that the Venus atmosphere rotates once every four days i.e. about 50 times as fast as the planet itself – certainly at the tope of its atmosphere, anyway.

But the main success lay in the astonishing photographs of Mercury: there were many thousands of these showing craters, rills and other features very similar to those on the Moon and Mars. The discovery of these tended to put paid to the idea that these impact features had been formed by the creation of the asteroid belt, though a later theory suggests, instead, that they were the result of the ejection of millions of tons of rocks from the planet Jupiter, "on at least two occasions."

Although Mercury is similar in external appearance to the Moon, it is thought to have a different interior and history.

SATELLITES IN THE CLASSROOM

A book of particular interest to science teachers, "Using Satellites in the Classroom: A Guide for Science Educators," has recently appeared in the United States. Copies are available free of charge to educational authorities requesting them on letterhead stationery: College level teachers should request copies from: Martin Davidoff, Catonsville Community College, Catonsville, Maryland 21228, USA. Pre-college teachers should send requests to: Julie Forbush, Editor, 'Air and Space,' Smithsonian Air and Space Museum, Washington, D.C. 20560, USA.

SOVIET AMATEUR RADIO SATELLITES

The Soviet Union launched its first two satellites intended for use by amateur radio operators on 26 October 1978. The two craft, designed by Soviet college students, rode as secondary payloads on the vehicle which orbited Cosmos 1045 from Plesetsk, writes Robert Christy. All three satellites achieved a 1,700 km, 120 minute orbit at 83 degrees inclination.

The satellites have a similar function to the U.S. launched OSCAR (Orbiting Satellite Carrying Amateur Radio) series. The latest of these, OSCAR 8 was carried as a secondary payload with Landsat 3 earlier in the year. The two Soviet payloads have been given names Radio 1 and 2 respectively.

Like OSCAR 8, the Radio satellites use frequencies in the 2 metre and 10 metre amateur radio bands. Uplink frequencies are in the band between 145.880 MHz and 145.920 MHz, the downlink frequencies are between 29.360 MHz and 29.400 MHz. Also, on 29.400 MHz there operates a Morse code identification beacon transmitting the letters "RS" with a maximum output power of 1.5 watts.

The maximum length of contact between any two stations using one of the transponders is 25 minutes and contacts between stations up to 8,000 km apart are possible.

BIS DEVELOPMENT PROGRAMME

NEW MEMBER DRIVE

INCREASED MEMBERSHIP is essential if our plans to enlarge and improve Society activities are to succeed.

ALREADY MANY IMPROVEMENTS are in hand – *Spaceflight* is now 48 pages, valuable new issues of *JBIS* are planned, our new offices are nearing completion, and all this with NO CHANGE in basic rates for THREE YEARS – FIVE YEARS in the case of overseas members who pay in dollars – incredible when prices around are doubling every four years.

Future plans depend heavily on an increased membership, so we are seeking help from every member to work with the Society to attract new members.

Society membership details will be sent immediately upon request, either by telephone or letter. All we need is the name and address to which they are to be sent.

IN APRIL WE WILL INCLUDE, IN THE CENTRE PAGES OF *SPACEFLIGHT*, FOUR APPLICATION FORMS. PLEASE PUT THESE TO GOOD USE.

Spaceflight is a good selling point. It now carries improved illustrations, a most active correspondence section, full-length articles on leading space developments and an extensive news coverage on:-

- International and national events in space.
- The US and USSR space programmes.
- Present and future developments in space. astronomy and related subject areas.
- Informative technical articles.
- News reports.
- Reviews and readers' correspondence.

Perhaps you can help in special ways too, e.g. by writing letters and articles to newspapers or magazines which introduce our address or mentioning that you yourself can be contacted by other readers.

PUBLICITY MATERIAL

Publicity Material can easily be obtained from the Society for distribution at meetings where the chance of obtaining new members is high. A quantity of application forms and specimen copies of SPACEFLIGHT will always be sent on request.

If available, a selection of issues will also be included suitable for setting out in the form of a small display.

MEDIA PUBLICITY

We work hard to secure publicity on radio, TV, and in the News Media, but the local press is often an untapped field which members could use to open discussions on space matters, e.g. by writing letters or getting friends to do so. Often this will bring down local reporters for an interview. There may be events, local connections or activities which would be useful for additional cover.

THE COSMONAUTS - 15

By Gordon R. Hooper

[Continued from January issue, page 17.

Lt. Colonel Miroslaw Hermaszewski

Miroslaw Hermaszewski, the first Polish cosmonaut, was born on 15 September 1941 in Lipniki, in south-west Poland, where his father Mirak Hermaszewski was a peasant smallholder. His father was killed during the Second World War, and the family moved to Wolowo near Wroclaw. Aircraft modelling became a hobby of Miroslaw at primary school, and he was granted a glider pilot's licence at the age of 17.

After graduating from school, he entered the Officers Flying School at Deblin, in 1961. He graduated from the School in November 1964, taking first place in the final examinations. He then served as a fighter pilot in the Polish Air Defence Force, and has logged almost 1500 hours in the air.

From 1969 to 1971, he attended a three year course in the aviation department of the Karol Swierczewski General Staff Academy, at the Faculty of Science. He graduated in 1971 and was promoted to Captain, and then held a number of commanding posts in various units of the Air Defence Force. In January 1975, he was promoted to Major, and made a squadron leader. In April 1976, he was appointed commander of a fighter regiment in the Polish Air Force.

While at school, and during his military service, he was an activist of the Socialist Youth Union, and in 1963, he joined the PZPR - the Polish United Workers Party.

Following the Intercosmos agreements on non-Soviet participation in manned spaceflights, a cosmonaut selection procedure was set up in Poland, and Hermaszewski was one of the men selected as candidates. Following exhaustive tests, he was one of the two Polish cosmonauts finally selected to be sent for training at the Yuri Gagarin Cosmonauts Training Centre in the Soviet Union, in December 1976.

During his period at Star Town, he was hospitalized with tonsilitis, and underwent a minor operation. He made a speedy recovery and quickly resumed his training with Pyotr Klimuk. The pair were launched into space onboard Soyuz 30, on 27 June 1978, and linked up with the Salyut 6 space-station, joining the crew of Kovalyonok and Ivanchenkov already onboard. Cosmonaut-researcher Hermaszewski and Cmdr. Klimuk spent nearly seven days onboard carrying out a programme of joint Soviet-Polish experiments. The crew then returned to Earth after a flight lasting 7 days 24 hours and 4 minutes.

Upon his return, Hermaszewski was promoted to Lt. Colonel, and awarded the Grunwald Cross, 1st Class, by the Polish Council of State. He was also awarded the title of Hero of the Soviet Union.

He married in 1965, and his wife is employed by the Polish Airline. They have two children, an 11 year old son, Yaroslav, and a 3 year old daughter, Emilia.

Miroslaw Hermaszewski has four sisters and two brothers. His hobbies include reading SF books, gliding, and track and field athletics. He is also a nature lover.

Colonel Zenon Jankowski

The second Polish cosmonaut, Zenon Jankowski, was born on 22 November 1937, in Poznan. After graduating from school, he entered an Air Force Officers School in 1956. He has also studied at the Karol Swierczewski General Staff Academy, and joined the PZPR - the Polish United Workers Party - in 1965. In 1976, he commanded a group of variable-geometry aircraft.

When the Polish cosmonaut selection programme began, Jankowski's "great technical knowledge, flying experience, tough mental build-up, and physical strength", lead him into the final group. He was eventually chosen as one of the two finalists, and was sent for cosmonaut training at the Yuri Gagarin Cosmonauts Training Centre in the Soviet Union, in December 1976.

He was assigned as back-up to Miroslaw Hermaszewski, and following a successful launch, Jankowski worked in MCC acting as a consultant (perhaps CapCom?) to the Senior Ground Flight Controller. Following the completion of the flight, Jankowski was promoted from Lt. Colonel to Colonel, and was awarded the Commanders Cross of the Polonia Restituta - or the Commodore Cross of the Order of Poland's Resurgence. This was in recognition of his services in the preparation of the flight and exemplary fulfilment of his tasks as consultant to the Flight Controller.

Wing Commander Jankowski is married, and has a 13 year old daughter.

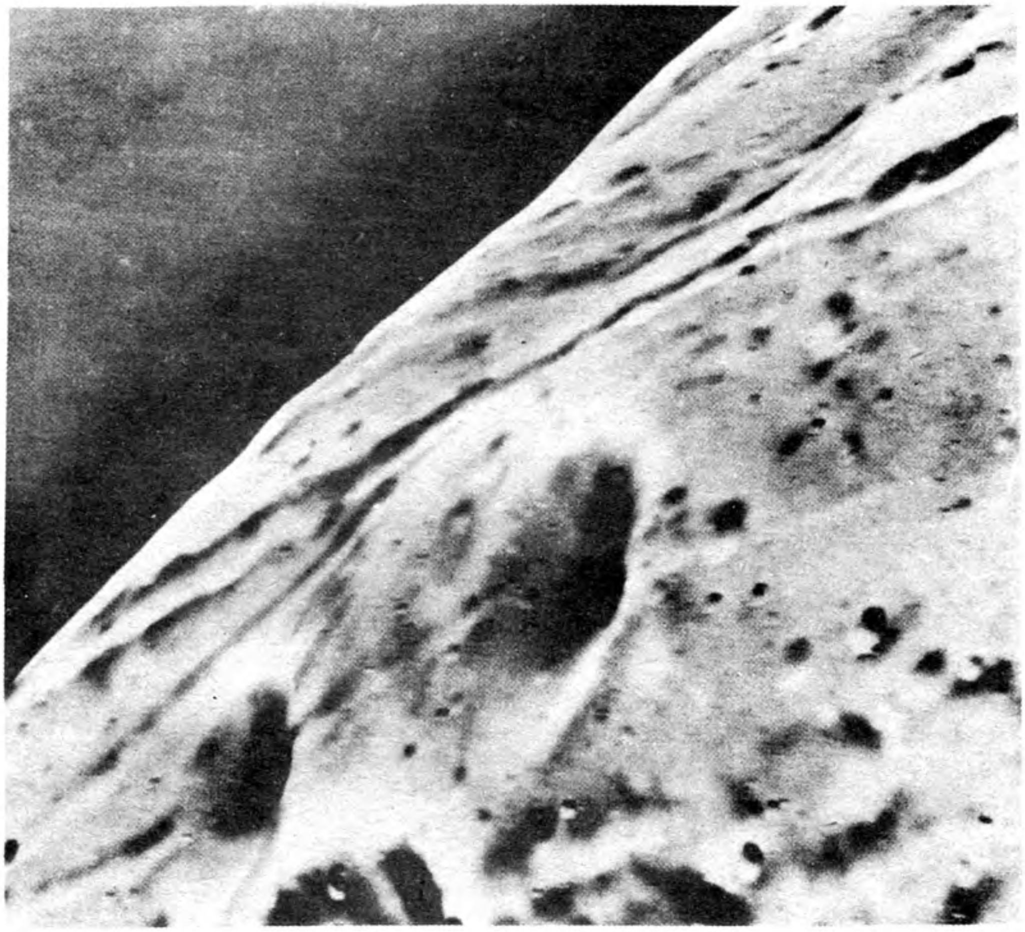
[To be continued

Lt. Col. Miroslaw Hermaszewski with his wife Emilia and son Miroslaw and daughter Emilia.

Novosti Press Agency

ASTRONOMICAL NOTEBOOK

By J. S. Griffith*



MARTIAN MOON. Viking Orbiter 1 took this remarkable close-up picture of Pnobos from a distance of 120 km (75 miles) on 20 February 1977. At that range the Martian moon is too large to be captured in a single frame. This picture covers an area 3 x 3.5 km (1.86 x 2.17 miles) and shows a region in the northern hemisphere that has striations and is heavily cratered. The striations, which appear to be grooves rather than crater chains, are about 100 to 200 metres (328 ft to 656 ft) wide and tens of kilometres long. Craters range in size from 10 metres (32 ft) to 1.2 km (0.74 miles) in diameter. The dark region above the limb of Phobos is an artifact of processing.

JPL, National Aeronautics and Space Administration

SOLAR SYSTEM

Grooves on Phobos

Phobos is scarred with impact craters and long linear grooves. Various explanations of the origin of the grooves are discussed and it is concluded that they are modified surface expressions of deep seated fractures produced during the formation of Stickney, the largest crater on Phobos.

As Phobos appears to be composed of a mechanically weak material [1] the irregular shape of the satellite is also explained by the severe impact that formed Stickney fracturing most of Phobos. Other small bodies in the Solar System, if composed of similar material (like primitive carbonaceous chrondrite meteorites) may be expected to have a similar pattern of grooves. In Ref. 2 it is pointed out that Deimos is free both from grooving and from any large craters – and may also be of different composition than Phobos.

[1] Chapman, C. R., Morrison, D. and Zellner, B., *Icarus*, **25**, 104-130 (1975).

[2] Thomas, P., Veverka, J. and Duxbury, T., 'Origin of the grooves on Phobos,' *Nature*, **273**, 282-284 (1978).

Fluffy Interplanetary Dust?

Recent micrometeorite flux curves, combined with data from the Helios space probes, is interpreted as indicating absorbing particles of fluffy structure as important components of the interplanetary dust cloud.

In Ref. 1 the recent data is discussed and particles in the size range 5-100 μm are found to contribute most to the visible zodiacal light, and to understand the scattering functions evident from observations such particles have rough or fluffy surface structures. Such fluffy particles have been collected from extraterrestrial dust [2] and have a slight enhancement of intensity towards backscattering and maximum of polarization towards 90° as is observed in the zodiacal light.

[1] Giese, R. H., Weiss, K., Zerull, R. H. and Ono, T., 'Large fluffy particles: a possible explanation of the optical properties of interplanetary dust' *Astron. & Astrophys.*, **65**, 265-272, (1978).

[2] Brownlee, D. H., *Lecture notes in physics*, **48**, 279 (1976).

* *Lakehead University, Thunder Bay, Ontario, Canada.*

The Missing Planet?

It has been suggested that 16 million years ago a planet of ninety Earth masses was situated in the asteroid belt and exploded. It is shown that, unfortunately, such an explosion would have completely destroyed life on the Earth. Three successive blasts would ensue, one by direct impact of debris from the explosion, one from the increased radiation from the Sun when stimulated by ejecta from the explosion and the third of radiation emitted by the nuclear explosion.

As geologically there is no discontinuity in life on Earth 16 million years ago, such an explosion in the late Tertiary period is ruled out. If the planet were gravitationally removed by an encounter with an intruder from interstellar space or from the unexplored reaches of the outer Solar System, then it would also remove all primaeval asteroids – and it is extremely improbable that such an encounter would leave the regularity of planetary orbits unchanged.

The new planet was hypothesized in Ref. 1 and arguments against the hypothesis presented in Ref. 2, where among the objections are:

(i) the age of the asteroidal belt as most authors contend it is as old as the Solar System.

(ii) the mass of the asteroid belt is of the order of one-thousandth of the Earth's mass.

(iii) the explosive removal of a sphere of ninety Earth-masses involves a vast outpouring of energy and would lead to retrograde orbiting material.

(iv) the presence of a large planet would quickly (less than one million years) mop up the asteroids – so new asteroids must have been formed by the explosions and a central explosion would lead to retrograde orbits, none of which exist today. A non-central explosion must have occurred.

(v) such an explosion would:

- (a) deposit 23.6 grams on each square centimetre of the Earth at an impact velocity larger than 60 km s^{-1}
- (b) boil a water layer of 21 m all round the globe and expand the shell of steam into space.
- (c) soak the depleted Earth with radiation.

(vi) a gravitational painless removal involves a probability of ejection of 1:4.5 x 10^{17} and would leave no asteroids.

"The final conclusion is that the hypothesis of the former existence and subsequent removal of a massive planet in the asteroidal belt cannot be supported with any degree of credibility."

[1] Ovenden, M. W., *Nature*, **239**, 508 (1972).
[2] Öpik, E. J., 'The missing planet,' *The Moon and the planets*, **18**, 327-337 (1978).

The Satellite of Pluto

Pluto appears to have a faint satellite with an orbital period of around 6.4 days and a mean distance of 15,000-20,000 km.

On 22 June 1978 J. W. Christy noticed that images of Pluto were consistently elongated, suggesting the existence of a satellite. In Ref. 1 this event and the subsequent ones that led to the discovery of Pluto's moon are reported. From earlier plates and further observations the phenomenon was found to be real. If it is indeed a satellite then the pole of the orbit lies close to the pole of rotation of Pluto and with a separation of about 15,000 km and a period of 6.4 days the mass of Pluto is about 0.0017 Earth masses, suggesting that Pluto is predominantly frozen volatiles, as are satellites of the outer major planets. The diameter of the satellite is about 0.4 times that of Pluto. It is suggested that a close encounter of Neptune with a large planet ejected a satellite of Neptune into an orbit that evolved into the present orbit of Pluto [2]. The violent event may have fragmented the satellite into two or more pieces. If this is the case then Pluto is certainly not a terrestrial-like planet.

[1] Christy, J. W. and Harrington, R. S., 'The satellite of Pluto,' *Astron. J.*, **83**, 1005-1008 (1978).
[2] Harrington, R. S and Van Flandern, T. C., in Press (1978).

STARS

Binary Transient X-ray Source

Precise elements of the first measured orbit of a transient X-ray source are given. The relatively wide orbit is proposed as the source of the slow rate of circularization and precludes steady mass loss, giving the transient nature of the source.

Various satellites including Uhuru, OSO 7, Ariel 5, SAS 3 and OSO 8 have given us much information on transient X-ray sources, and efforts have been made to explain the observations in terms of accreting stars in binary orbits. In Ref. 1 extended SAS 3 timing observations of 4U 0115+63 are reported and the first definitive measurements of the binary orbit of a transient X-ray source are presented. The orbital separation is of the order of 150 light seconds with period 24.3 days. The system appears to consist of a Be star as companion to the X-ray pulsar. Mass transfer is certainly not due to Roche lobe overflow, but to spontaneous mass loss from the companion. X-ray transients are collapsed stars in binary systems substantially wider than the more persistent X-ray binaries. This wide separation results in sporadic rather than continuous mass transfer onto the X-ray star.

[1] Rappaport, S. *et al*, 'Orbital elements of 4U 0115+63 and the nature of the hard X-ray transients,' *Astrophys. J.* Letters, **224**, L1-L4 (1978).

New Stars and H_2O

VLBI observations of twelve galactic water vapour sources in regions of recent stellar formation revealed concentrations of water vapour in regions of activity about 10^{16} cms in size. Each centre of H_2O activity is identified as the envelope of a young, massive star.

The work reported in Ref. 1 utilized very long baseline interferometry with radio telescopes at Simeis (Crimea), Onsala (Sweden), Effelsberg (Federal Republic of Germany), Haystack and Maryland Point (USA) and attained a positional accuracy of about 1 milli arc sec for observations at 22 GHz.

[1] Genzel, R. *et al*, 'Structure and kinematics of H_2O sources in clusters of newly formed OB stars,' *Astron, & Astrophys.* **66**, 13-29 (1978).

Herbig-Haro Objects

The bright globular Herbig-Haro objects are interpreted as spherical non-stationary shock waves.

These condensations have been considered for a long time as regions of protostellar formation. In Ref. 1 it is shown that the similarity between the spectra of some supernova remnants and the emission line spectra of some HH condensates, together with the high velocity of the condensates with respect to the surrounding interstellar gas confirms the hypothesis that HH spectra are formed in cooling regions behind shock waves. As the brightness of an individual condensate changes with a time scale of the order of 10 years an explanation of the behaviour was sought. The author shows that interpretation of the bright variable nebulae as due to shock waves moving into an ambient interstellar gas can explain many of the features. However the typical small sizes of the condensate within HH objects seems to indicate the need for energy sources within the individual condensation.

[1] Bohm, K. H., 'The shock wave interpretation of individual condensations in Herbig-Haro objects,' *Astron. & Astrophys.*, **64**, 115-118 (1978).

Impact of a Neutron Star with a Supergiant

The penetration of a one solar mass neutron star into a supergiant companion of sixteen times the mass is investigated.

If one star in a moderately close binary is engulfed in the atmosphere of its more rapidly evolving companion then frictional drag may transfer some of its angular momentum to the envelope of the evolving star thus leading to an inward spiral, ending up with two close evolved stars with very small total angular momentum. The problem of two stellar cores within one envelope is considered in Ref. 1. If the system has a short period, the primary can accommodate the infalling neutron star with a quasi-static adjustment of its structure. A major phase of core expansion, induced by the large rate of energy dissipation, led to the final plunge of the neutron star towards the centre, giving a giant with a neutron star core. For the long period case the envelope of the giant was ejected and the system could eventually form a binary with two neutron star components.

[1] Taam, R. E., Bodenheimer, P. and Ostriker, J. P., 'Double core evolution, 1. A 16 $M_{\odot}$ star with a 1 $M_{\odot}$ neutron star companion,' *Astrophys. J.*, **222**, 269-280 (1978).

GALAXIES

Supercluster of Galaxies

Analysis of 238 galaxies around the two rich clusters of galaxies Coma and A1367 revealed that the two clusters are engulfed in a common supercluster. Galaxies were found to occur in groups with very few isolated galaxies. Regions of space with radii of the order of 1000 Mpc were empty. It is deduced that all galaxies are or once were members of groups and clusters, with those few isolated galaxies that exist today resulting from tidal disruption.

This work is based on observations using the Kitt Peak 2.1 m telescope and is reported in Ref. 1. The observations were combined with previous ones to give a spatial picture of the region. Groups of galaxies have separations much larger than their radii and it is pointed out that for any cosmological model to explain this clumped nature it is necessary that matter be present in between the galaxy groups, but in some other form – as faint galaxies or perhaps hot or cold hydrogen gas.

If Tifft's band theory is correct then it is not possible to interpret directly redshifts as distances, and the spatial pictures of Coma and A1367 will need modification.

[1] Gregory, S. A. and Thompson, L. A., 'The Coms/A1367 supercluster and its environs,' *Astrophys. J.*, **222**, 784-799. (1978).

QSO Redshifts

Redshifts of galaxies near to QSO's were obtained and 13 galaxies found to have redshifts within 1000 km s^{-1} of that of the neighbouring QSO. The probability of such agreement is less than 1.5 x 10^{-6} unless the redshifts of galaxy and QSO are linked. The cosmological nature of QSO redshifts is thus a virtual certainty.

The conventional interpretation of QSO redshifts as cosmological has been debated many times (see for example Refs. 1, 2, 3 and 4). A statistical test of the cosmological neture of QSO's is given in Ref. 5 where neighbouring galaxies have their redshifts compared to corresponding QSO's.

Very strong evidence for the cosmological interpretation of QSO redshifts is found.

[1] Burbidge, G. R., *Nature Phys. Sci.*, **246**, 17 (1973).
[2] Field, G. B., Arp, Had Bahcall, J. N., *The redshift controversy*, Benjamin (1973).
[3] Rowan - Robinson, M., *Nature*, **262**, 97 (1976).
[4] Weedman, D. W., *Quart. J. Roy. Ast. Soc.*, **17**, 227 (1976).
[5] Stockton, A., 'The nature of QSO redshifts,' *Astrophys. J.*, **223**, 747-757 (1978).

Galactic Cannilbalism

A numerical simulation of the evolution of massive cluster galaxies due to the accretion of other galaxies is presented. A 'normal' galaxy is found to resemble a cD giant after several such accretions. The multiple nuclei sometimes found in cD galaxies is explained as the undigested remnants of cannibalized components.

Close encounters between galaxies in the compact cores of centrally condensed clusters have been shown to have various major effects. Faint outer envelopes of galaxies will be stripped off and distributed throughout the cluster core; ringed galaxies, mouse-tail galaxies, bridged pairs and other strange forms may be produced; giant galaxies may grow by accreting their neighbours where a grazing encounter and dynamical friction leads to inward falling spirals and disruption with constituent stars distributed throughout the captor. It is this aspect of cannibalism that is further investigated in Ref. 1.

The process causes the brightest galaxy of a cluster to progressively grow in brightness, altering the expected redshift-magnitude diagram. It is found that dynamically produced accretion may account for many of the observed properties of bright cluster galaxies, particularly the cD giants. An evolving galaxy's metric magnitude quickly reaches a limiting value, explaining why it is found observationally that the brightest galaxies in clusters of widely differing densities and relaxation times (hence varying rates of evolution) display small variations in measured luminosities. Undigested lumps observed in many cD galaxies with multiple nucleii along their long axis may be remnants of half eaten galaxies.

In addition it is suggested that elliptical galaxies are those swept clear of interstellar gas by collision and that SO galaxies are similarly formed by collision but after a stellar

disk has had time to form.

[1] Hausman, M. A. and Ostriker, J. P., 'Galactic cannibalism. III The morphological evolution of galaxies and clusters,' *Astrophys. J.*, **224**, 320-336 (1978).

QUASARS

Quasi Stellar Objects

The question of the origin of the strong absorption lines found in the spectra of an increasing number of QSO's remains unanswered. It may be from a cause intrinsic to the QSO such as gas ejected from the QSO falling on it. Alternatively, if the QSO's are at cosmological distances the absorption may be extrinsic and caused by intervening galaxies, galactic halos or intergalactic clouds. For a local origin of QSO's the absorption must be intrinsic, arise in our own Galaxy, or in the near vicinity (within 200 Mpc). If the QSO's lie at cosmological distances, the absorption may be both intrinsic and extrinsic. In an attempt to settle this question the spectra of six QSO's were studies. Unfortunately no definitive answer was evident, but some interesting results and challenges to advocates of the cosmological hypothesis are presented.

The analysis presented in Ref. 1 is based on observations with the image tube spectrograph to the 4 m Mayall reflector at Kitt Peak National Observatory. Six QSO's were studied in detail. When endeavouring to identify lines in a spectrum that consists of the amalgamation of many absorption lines with several different redshifted systems there are obvious difficulties, and the authors admit that about 60% of the lines remain unidentified. However, they are able to draw various conclusions. In five of the six QSO's studies there are a large number of redshifts covering a wide range in z. The relatively large number of comparatively small (less than one) redshifts in absorption can only be explained by intervening galaxies if the average size of the galactic halos is of the order of 0.5 Mpc., and such small redshifts should be found in all QSO's with emission z's larger than unity. Some absorption redshifts may be larger than the emission redshift, a result inexplicable in terms of either hypothesis. Interstellar calcium H and K lines are rarely seen in QSO spectra.

[1] Roberts, D. H. *et al*, 'A study of the absorption-line spectra of six high-redshift quasi-stellar objects,' *Astrophys. J.* **224**, 344-367 (1978).

BLACK HOLES

A Model Cygnus A

The radio source Cygnus A is an extragalactic radio source with two radio lobes. Black holes of large mass are proposed as the source of the relativistic electrons, thermal plasmas and magnetic fields found in many radio sources similar to Cygnus A, and in the particular case of Cygnus A the mass of the supermassive black holes required is of the order of 10^{10} solar masses.

In Ref. 1 it is pointed out that the recent discovery of optical objects close to the centres of various double radio sources confirms the theory that such doubled lobed sources can be powered by supermassive black holes.

The jet of M 87 contains within itself several knots. One of them is emitting synchroton radiation and is probably powered by a black hole. It is taken as the example of what a supermassive black holes looks like from the exterior and compared with the components of Cygnus A. The passage of a supermassive object will leave a tube of plasma along its path. The total mass inside each lobe is about 3×10^8 solar masses, and as the outward wind from the black hole is presumably accompanied by swallowing of disk matter into the black hole at a somewhat higher rate, the total mass of the supermassive around 10^{10} solar masses.

Ejections of black holes of similar mass, together with their accompanying gaseous disks from supergiant elliptical galaxies provides a consistent picture of the double radio source phenomenon.

[1] Valtonen, M. J., 'A model for Cygnus A: a radio source powered by M 87 type knots,' *Astrophys. J.*, **222**, 78-83 (1978).

COSMOLOGICAL THEORY

Astrophysics and the Heavy Stable Neutron Lepton

High-energy particle physicists have predicted the possible existence of a stable neutral lepton, with a mass of a few GeV/c^2. The possible cosmological consequences include the dominance of the present mass density in the Universe by the lepton, as it is a favoured candidate for the material in galactic halos and for the mass required to bind the great clusters of galaxies.

Until recently the known elementary particles were the electron, the muon, their two associated neutrons and their antiparticles.

A recent prediction adds the existence of an absolutely stable heavy lepton.

In Ref. 1 it is pointed out that such massive stable neutrinos and their antiparticles would dominate the mass density in the present Universe. As they do not react they would not sensibly affect primordial nucleosynthesis but could serve well to account for the missing 40% of the mass required to make the extended halos of spiral galaxies and to bind the great clusters gravitationally.

It is found to be possible to detect the missing mass, if it is of the form of these stable leptons, by x-ray observations. "...the question of the nature of the missing mass might well be decided by Earth-based particle accelerators rather than optical telescopes. Measurements of a stable heavy neutrino of about a few GeV mass will then have the astrophysical consequences pointed out above."

[1] Gunn, J. E. *et al*, 'Some astrophysical consequences of the existence of a heavy stable neutral lepton,' *Astrophys. J.*, **223**, 1015-1031 (1978).

The Hubble Diagram

Measurements of redshifts and magnitudes of faint galaxies were made and analysed to give the first significant evidence for curvature of the Hubble diagram. To arrive at a final decision on the nature of the Universe we still need to know how galaxy brightness changes with time and/or the deceleration parameter q_o.

It is now almost fifty years since the original Hubble diagram was produced, and the authors of Ref. 1 use their recent observations of redshifts and magnitudes of faint galaxies to extend the diagram by a factor of greater than 200 in redshift from the original parameter. The data have now begun to show a significant departure from linearity.

The Hubble diagram is a plot of redshift against distance and the authors of Ref. 1 restrict their discussion of the trend to redshifts less than z equal to 0.4, to ensure that distortion effects such as selection of only the brightest objects are not operative.

If there has been no significant luminosity change during

the last one-fourth of the Hubble time (4 x 10^9 years if the Hubble constant is 55 km s^{-1} Mpc^{-1}) then the Universe appears to be closed, 12 x 10^9 years old and due to collapse again in 60 x 10^9 years. If the deceleration parameter is nearly zero, then evolving galaxies are the norm with a dimming of about half a magnitude during the last 5 x 10^9 years, and the Universe is open and nearly empty.

[1] Kristian, J., Sandage, A. and Westphal, J. A., 'The extension of the Hubble diagram II. New redshifts and photometry of very distant galaxy clusters: first indication of a deviation of the Hubble diagram from a straight line,' *Astrophys. J.*, **221**, 383-394 (1978).

Band Theory

Over the past six years W. G. Tifft has been adding to the evidence for redshift-magnitude "bands". Band theory and the expanding Universe theory are contradictory and the distinction between the theories must be made by observational tests. Observations of the Coma and A2199 clusters were first examined, and the study is extended to Perseus and the A1367 cluster in Ref. 1. It is found in Ref. 2 that the graphs of magnitude against redshift for individual galaxies in the clusters demonstrate a banded appearance, with the bands having constant slope.

The major properties of the redshift-magnitude bands are:

(a) galaxies appear to populate an absolute band system with standard band slope and band locations in total magnitudes.

(b) vertical sequences of galaxies associate with band heads.

(c) radio sources associate with band heads.

(d) morphology varies along bands, with later types preferring higher redshifts.

(e) the band pattern tends to brighten slightly and shift towards higher redshifts as one proceeds radially outwards in clusters.

The redshift seems to be a nonvelocity property of matter itself and galaxies are combinations of states undergoing nonviolent expansion. The evolutionary model proposed by Tifft has galaxies emerging from singularities and evolving by expansion. The time of emergence is an inverse function of redshift with lower redshift objects emerging later in time. Galaxies brighten rapidly towards a fairly standard absolute luminosity for any given band to provide the vertical sequences. At the transition from emergence phase to the band proper brightening stops. One sympton of the transition is the radio source. Galaxies continue to expand and fade slowly away. The fading rate, coupled with the rate of band growth towards lower redshift produces the sloping band. Gradual expansion and dissipation of the initially compact nucleus provides some overall morphological trend with time – along a band.

The author proposes to use this preliminary theory for development of further tests of the band phenomenon.

[1] Tifft, W. G., 'Redshift-magnitude bands and the evolution of galaxies. I. New observations,' *Astrophys. J.*, **222**, 54-60 (1978).
[2] Tifft, W. G., 'Redshift-magnitude bands and the evolution of galaxies. II. Data analysis,' *Astrophys. J.*, **222**, 421-434 (1978).

A Computer Model of the Universe!

A static computer model universe was developed to match the characteristics of the galaxy distribution in the Lick survey. "Galaxy" positions in a three dimensional clustering hierarchy were assigned by the model and it also fixed absolute magnitudes and projected angular positions of objects brighter than m = 18.9 onto the sky of an imaginary observer. Over 7.5 x 10^6 galaxies were simulated. It was possible to produce a galaxy map that reasonably resembles visually the Lick data.

From observations it is possible to deduce a clustering hierarchy pattern. In Ref. 1 the process is reversed, and starting with hierarchical clustering as a prescription for the positions of galaxies in a simulated "universe". The authors emphasize that we do not understand how the eye judges texture and patterns, so visual resemblance is somewhat difficult to quantify and hence there is no prescription for adjusting map parameters to render the map more accurate.

The final result is a reasonable and pleasing approximation to the Lick map, and several conclusions about the actual distribution of galaxies are drawn.

[1] Soneira, R. M. and Peebles, P. J. B., 'A computer model universe: simulation of the nature of the galaxy distribution in the Lick Catalog,' *Astron. J.*, **83**, 845-861 (1978).

Stellar Formation

The evolution of an interstellar collapsing cloud is followed through intermediate fragmentation stages to stellar multiple systems. Angular momentum is lost primarily through the formation of ring or toroidal subsystems.

One of the major problems in attempting to explain the formation of stars from collapsing interstellar clouds is how to dispose of the angular momentum. The specific angular momentum of mass elements has to be reduced by a factor of around one million to enable rotationally stable stars to condense. In Ref. 1 the problem is solved by the formation during the collapse of a rotating ring which subsequently fragments into two condensations. During the collapse the initial cooling phase is due to an increase of density while the cloud remains optically thin to its own radiation. Then the temperature remains around 10K while the density increases in an isothermal collapse stage. This is followed by an adiabatic collapse during which the temperature increases to 2000K and the density to 10^{-7} g cm^{-3}. A further collapse is induced by dissociation of molecular hydrogen to a density of the order of 10^{-2} g cm^{-3}. Finally a core develops in hydrostatic equilibrium and the remaining mass of the fragment accretes onto the core.

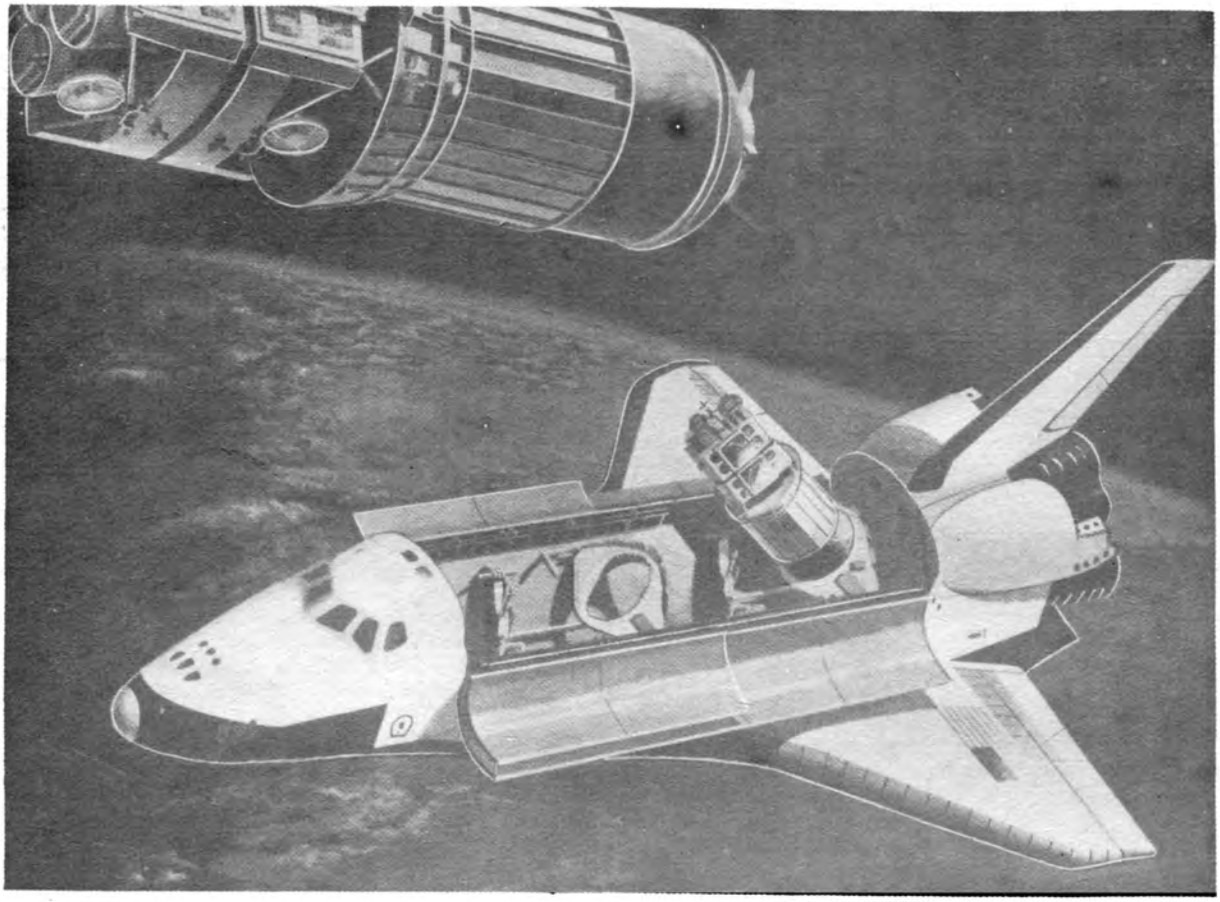
It is found that at the molecular cloud stage and at the T Tauri stage the calculated rotational velocities are in rough agreement with observations.

The fragmentation of isothermal rings and subsequent star formation is considered in more detail in Ref. 2. It is found that ring fragmentation as a result of non-axisymmetric perturbations is rapid, with blobs well formed within approximately one-half of a revolution period. Collapse is also nonhomologous, leaving accretion centres. Ring fragmentation into two or three blobs is preferred, a feature that agrees well with the observation that most stars occur in multiple systems. A massive cloud is presumed to form a ring and then blobs, within which rings and then blobs form, and so on.

[1] Bodenheimer, P., 'Evolution of rotating interstellar clouds. III. On the formation of multiple star systems,' *Astrophys. J.*, **224**, 488-496 (1978).
[2] Norman, M. L. and Wilson, J. R., 'The fragmentation of isothermal rings and star formation,' *Astrophys. J.*, **224**, 497-511 (1978).

SPACE REPORT

A regular monthly review of Space Events and Technical Trends



SPACE TUGS. This artist's impression shows two Inertial Upper Stage 'space tugs' each carrying a NASA Tracking and Data Relay Satellite (TDRS) being deployed from the cargo bay of the Space Shuttle. The Boeing-built IUS has been selected to take four of the six TDRS payloads from the Shuttle's low Earth orbit to geo-stationary orbit. The IUS will be mounted on a rotating frame and be ejected by a spring-loaded mechanism. The solid-propellant IUS is being developed by The Boeing Company for both NASA and the U.S. Department of Defense missions under contract from the U.S. Air Force Space and Missile Systems Organisation.

Boeing Aerospace Company

SPACE SHUTTLE STATUS-2

With a target date of 28 September 1979 for the first manned orbital flight of NASA's Space Shuttle, fabrication and testing of components continue at various locations throughout the United States.

Measures have been taken to accelerate production and installation of the Thermal Protection System (TPS) tile for Orbiter 102. Staffing has been increased at both the Rockwell International facility at Palmdale, and at the Lockheed plant at Sunnyvale, California, where the tiles are made. New tile inspection equipment has been obtained to improve productivity of the tile.

Testing of the Space Shuttle Main Engine (SSME) continues at NASA's engine test facility near Bay St. Louis. Between 10 September and 12 October, 13 test firings were conducted on two engines for a total of 3,794 seconds. Ten of those tests reached rated power (RPL), accumulating 3,096 seconds.

Three of the tests were prematurely shut down, two for instrumentation problems and one (first test on engine 0006) when propellant priming of the engine oxidizer system occurred out of sequence and caused damage to a fuel turbopump turbine and the main injector of the engine.

Results of an extensive hardware inspection of engine 005, after a series of 16 test firings in August and September, have been described as very satisfactory by project engineers at NASA's Marshall Space Flight Center.

Total engine testing up to 11 October shows 350 engine test firings for a total time of 26,530 seconds, including 8,969 seconds at RPL.

Full duration testing of the complete main propulsion system, a cluster of three engines, is scheduled for early 1979 when the first manned orbital flight configuration engines become available.

The third static test firing of a solid rocket booster (SRB) motor was conducted on 19 October at the Thiokol Chemical Corporation's test site near Brigham City, Utah. Early data indicates a successful test firing. Gimballing of the motor nozzle also appeared to be satisfactory from early test data.

Meanwhile, all elements of a Space Shuttle have been mated for the first time – two SRB's, an external tank and an orbiter (101) – for vertical vibration testing at the Marshall Center. The testing is to verify that the Space Shuttle structure will perform during various stages of the flight as predicted.

GAMMA RAY OBSERVATORY

NASA tentatively has selected five scientific experiments for its Gamma Ray Observatory, a planned 1984 mission designed to explore the world of gamma rays – the most energetic form of radiation known to man.

The Earth-orbiting observatory will combine instruments for the detection of gamma rays in a variety of forms including very high energy gamma rays from pulsars, nuclear gamma rays and gamma ray bursts.

Information returned is expected to provide a much deeper understanding of the nature of supernovae, pulsars, quasars and radio galaxies, the character of the Universe at an early time, and the possible existance of antimatter in the Universe.

Scientists also hope to learn more about the state of incredibly dense matter which makes up such objects as neutron stars – matter so compressed that a teaspoonful of it would weigh millions of tons.

The data may also shed more light on the nature of gamma ray bursts, erratic pulses of gamma rays that appear every month or so and flash across the Solar System. Their origin is a mystery.

NASA officials emphasized that GRO has not yet been approved by Congress, but early solicitation of scientific participants and investigations allows for mission definition and and a prompt start when approval is received.

Like X-rays, gamma rays are a form of electromagnetic radiation (photons), as is ordinary light, but having extremely high energy and correspondingly short wavelength (less than 10^{-11} cm). At maximum strength, a gamma ray unit packs several million times as much energy as a unit of visible light.

Unlike X-rays, however, which are typically emitted by hot gas, gamma rays are believed to come from the core of the phenomenon, produced by special processes which are nuclear in character. Gamma ray astronomy allows scientists to investigate these special processes.

Because of their basic nuclear character, gamma rays were recognized after World War II as perhaps the most important single kind of space research possible. But until recently, all astronomy observations were of atoms, ions and molecules and their emissions. A long programme of balloon research proved rather disappointing, with only hints that gamma ray sources were being detected. Then a small experiment on an Orbiting Solar Observatory detected the first certain gamma rays. This gave scientists the confidence to launch in 1972 the Small Astronomy Satellite 2 (SAS 2) with a small detector for very high energy gamma rays. This spacecraft, along with COS B (1975) and the first High Energy Astronomy Observatory (HEAO 1), provided the basic data which will be exploited by the more powerful GRO.

Dr. Noel W. Hinners, NASA Associate Administrator for Space Science, says:

"We are now in a position to move forward and reap the benefit of this long effort. With the Gamma Ray Observatory, we will usher in the era of nuclear astronomy. We will have a powerful probe of the high energy universe."

GRO will be managed by Goddard Space Flight Center at Greenbelt, Maryland. The observatory will be carried into a planned orbit of 400 to 500 km (250 to 300 miles) by the Space Shuttle from Cape Canaveral, Florida. The planned altitude was chosen to be as low as possible consistent with a minimum two-year design lifetime.

Scientific investigation selected by NASA and the Principal Investigators for each are as follows:

Broad Line Gamma Spectrometer

Principal Investigator, Dr. James D. Kurfess, Naval Research Laboratory. This instrument will perform detailed spectral and temporal studies of intermediate energy gamma-ray sources, including gamma-ray bursts, solar flares and sources of broad line emission.

Narrow Line Gamma Ray Spectrometer

Principal Invesigator Dr. Laurence E. Peterson, University of California, San Diego. This instrument will measure gamma-ray line intensities, continuum spectra and their time-varying objects, and the diffuse galactic and extragalactic diffuse emission.

High Energy Gamma Ray Detector

Principal Investigator, Carl Fichtel, Goddard Space Flight Center. This is a telescope to search for discrete gamma-ray sources and measure their intensity, spectrum, position and time variability. The telescope will also obtain better positions for known sources, and will study the spectrum and structure of the high energy diffuse galactic emission and isotropic diffuse background.

Medium Energy Double Compton Telescope

Principal Investigator Dr. V. Schoenfelder, Max Planck Institute for Extraterrestrial Physics, Garching, Germany. This instrument will study the spectrum and time variability of medium-energy point sources, investigate the diffuse galactic emission and isotropic diffuse flux in this energy range, and search for broadened line emission from both point and diffuse sources.

Transient Gamma Ray Monitor

Principal Investigator, Dr. Gerald J. Fishman, Marshall Space Flight Center, Huntsville, Alabama. This experiment will measure the frequency *versus* size distribution of gamma ray bursts, provide single-station burst locations to within several degrees and precise timing of stronger bursts to obtain arc second positions (in conjunction with other satellites), measure variations in intensity and spectrum of bursts and other transient events with a temporal resolution of 0.1 milliseconds and continuously monitor the stronger X-ray and gamma ray sources for transient phenomena.

SOLAR ARRAY WING

NASA's Marshall Space Flight Center has awarded a $2.7 million contract to Lockheed Missiles and Space Company of Sunnyvale, California, for development and delivery by May 1980 of a flight experiment solar array wing. The experiment is expected to be carried into orbit by the Space Shuttle the following November.

The experiment is regarded as a significant step toward producing large amounts of power in space. It is intended to verify the structural and dynamic characteristics of the solar array wing, its electrical performance and the readiness of solar array technology for planetary and Earth orbit Shuttle payload applications.

The solar array wing, measuring 32 metres (105 ft) long and 4 m (13.5 ft) wide, will be folded and stored in the Shuttle's cargo bay during launch. Attached to the cargo bay, it will be extended to its full length and retracted several times during the test.

When fully extended and fully populated with solar cells, the array's 82 panels convert energy from the Sun to produce 12.5 kilowatts of power. For the experiment flight test, only three of the panels will be active.

Demonstration of the experimental solar array wing will pave the way for the use of this technology for power augmentation for Space Shuttle and Spacelab to extend mission duration and later for a solar electric propulsion stage.

NASA's Office of Aeronautics and Space Technology is directing the solar array programme as part of a larger programme which is developing solar electric propulsion for long-term missions in the mid-1980's.

The solar array technology is relevant to Shuttle payload applications such as a space construction base, satellite power systems, power modules and others.

OBTAINING LANDSAT DATA

Two new reference systems that will provide users with quick and inexpensive access to Landsat data have been developed by the EROS Data Center with support from the National Cartographic Information Center. Called the Landsat microCATALOG and Landsat microIMAGE systems, these products use standard microfiche records to replace the paper catalogues and roll microfilm of "browse" images that previously were the basic reference tools for Landsat information.

Indexing for both microfiche systems is referenced to the Landsat Worldwide Reference System (WRS), a global network of *paths* and *rows* by which all Landsat scenes can be geographically located. With the Landsat 3 time frame, there are 251 *paths* and 248 *rows* in the WRS network, which provides an array of 62,248 *path-row* intersections (nominal scene centres) around which Landsat scenes can be clustered.

WRS indexes show the locations of all these "nominal scene centres". These indexes show both the daytime (descending node) centres and the nighttime (ascending node) centres. Using the WRS indexes for search and retrieval merely requires that the path-row intersections in the area of interest by identified. The appropriate microfiche can then be found in either the microCATALOG or microIMAGE file.

The microIMAGE issued in 1978 is a daily record of all Landsat scenes acquired along a *path/zone*. Band 5 MSS images are shown where available; Band 8 is shown for Landsat-3 nighttime acquisitions. The Landsat microIMAGE offers several advantages over the 16mm roll microfilm "browse" record:

1. The microIMAGE is self-indexing, whereas the roll film requires an external index for cassette and frame location.
2. Each microIMAGE is dedicated to daily acquisitions along specified *paths;* images on roll microfilm are randomly sequenced.
3. The microIMAGE are available for distribution within three weeks of scene acquisition; scenes on roll microfilm are delayed two-to-five months from date of acquisition.

The Landsat microCATALOG and microIMAGE fiche are divided into *zones* within the WRS. To achieve an acceptable image quality in the microIMAGE fiche, a maximum of 60 images per fiche can be recorded. *Zones,* therefore, reflect this grouping of microframe positions within each fiche. Each position is dedicated to a specific *row* within the *path* and *zone.* The *zone* organization is as follows:

North Zone (Day): 80°N. Lat. to the Equator, Rows 1-60
(Night): Equator to 80°N. Lat, Rows 184-243

South Zone (Day): 28°N. Lat. to 57°S. Lat, Rows 41-100
(Night): 57°S. Lat. to 28°N. Lat. Rows 144-203

The *row* overlap between north and south zones provides complete country coverage within one of these two Zones. The Polar Zone includes the *rows* that fall south of the South Zone boundary and north of the North Zone boundary.

The microCATALOG is a cumulative listing of descriptions of all Landsat accessions indexed by *path* and *zone.* There is at least one microCATALOG for every *path/zone;* each microCATALOG is updated periodically until the number of listings (accessions) approaches the saturation limit of any microframe on the fiche. In such a case, date ranges are established to organize the number of accessions multiple microfiche records.

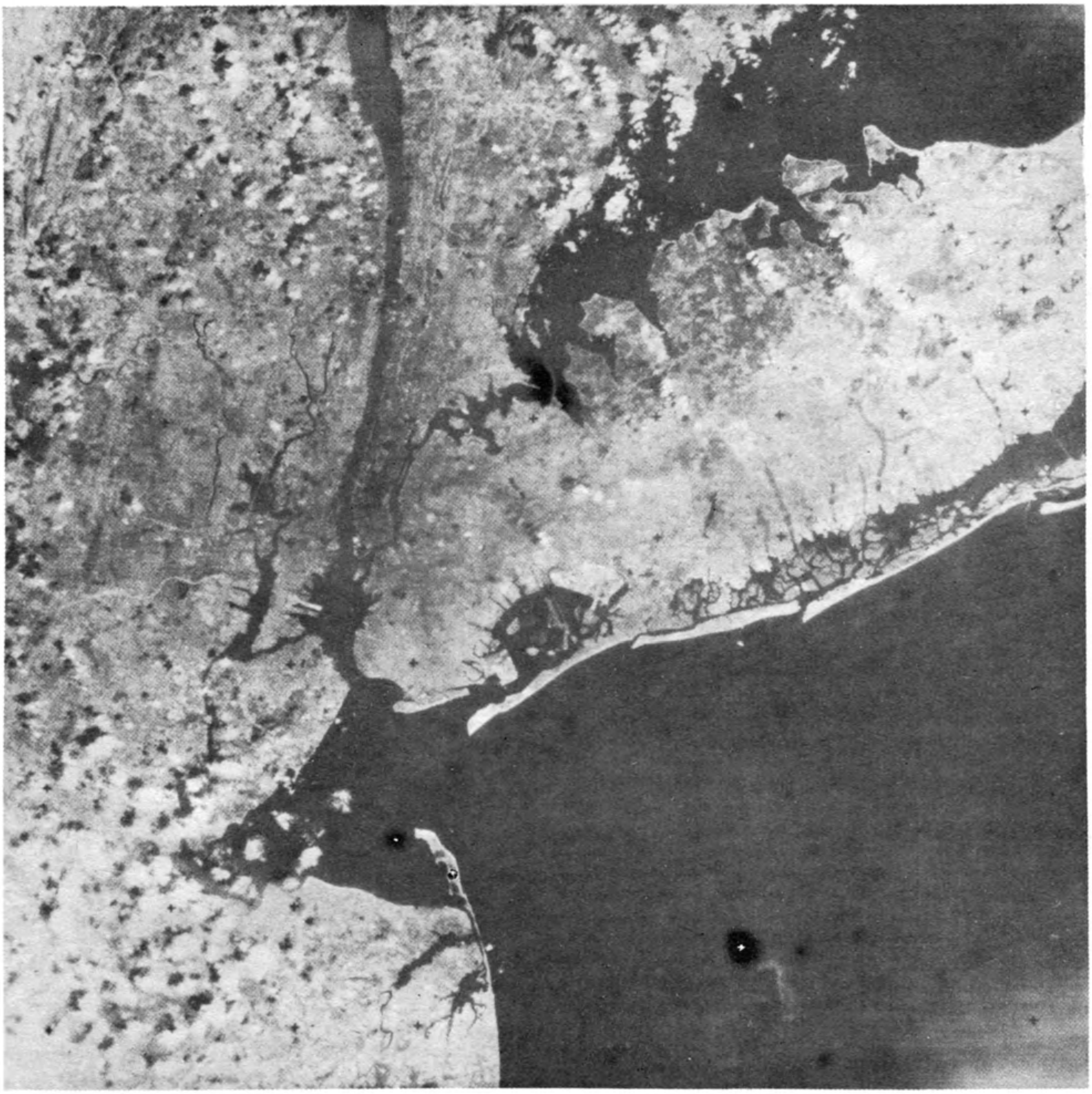
For example, North and Central America (*paths* 1 through 97 in the North Zone) consists of the following date ranges: 1972-74, 1975, 1976, 1977, and 1978. Thus five microCATALOG fiche are required to show complete historical Landsat coverage along a *path* in North America.

The Landsat microCATALOG is available from the EROS Data Center now. A packaging plan has been devised which allows users to tailor their catalogue requirements to specific geographic areas. The microCATALOG can be ordered as a complete Current Catalog, or by one-year subscriptions. Individual fiche are priced at $.20 with a $5.00 minimum order. This price schedule is shown in the following table.

For smaller orders, note the *path/zone* of interest

AREA	ONE-YEAR SUBSCRIPTION[1] Update	Price	CUR. CATA. PRICE[2]
World	Monthly/Quarterly	$750	$260
North	Monthly/Quarterly	350	140
South	Quarterly	200	70
Polar	Quarterly	200	50
U.S.A. (48). C. America	Monthly	95	40
Alaska, Hawaii	Monthly	95	40
South America	Quarterly	25	7
Central and South America	Quarterly	45	10
Australia and S. E. Asia	Quarterly	35	10
Europe and North Africa	Quarterly	35	12
India, Burma and Pakistan	Quarterly	25	10
Middle East	Quarterly	20	10

[1] One-year subscription: Update cycle is monthly for Paths 1-97, North Zone, and quarterly for the rest of the world.
[2] Current Catalogue price: These catalogues include all accessions to the date of order, including the most recent update.



NEW YORK CITY AND NEW JERSEY. Landsat 3 'snapped' this detailed photograph of the New York City area on 31 March 1978 from an altitude of 917 km. The picture, which includes an area 80 km square, covers from north to south White Plains, New York to Monmouth Beach, New Jersey (far left). Some other landmarks include: • Hudson River (top left centre to middle left centre). • Tappan Zee Bridge (top, left centre). • East River (left centre). • Central Park (small dark dot, left centre). • Newark Bay and Newark International Airport (left, centre). • Jamaica Bay and John F. Kennedy International Airport (centre). • Coney Island (lower left centre). • Staten Island and Verrazano Bridge (lower left). • Route 22 (far left). • Long Island South (upper right). • Small white circles are puffy clouds. • Atlantic Ocean (lower right corner). The camera which took this image can capture objects of about 46 metres, or areas as small as half an acre.

National Aeronautics and Space Administration

multiply the total by $.20. Twenty-five (25) microfiche can be ordered for the minimum $5.00 charge. If selected date ranges are important, this should be specified. Send orders and/or inquiries to User Services, EROS Data Center, Sioux Falls, SD 57198.

OXFORD EXPERIMENT ON NIMBUS 7

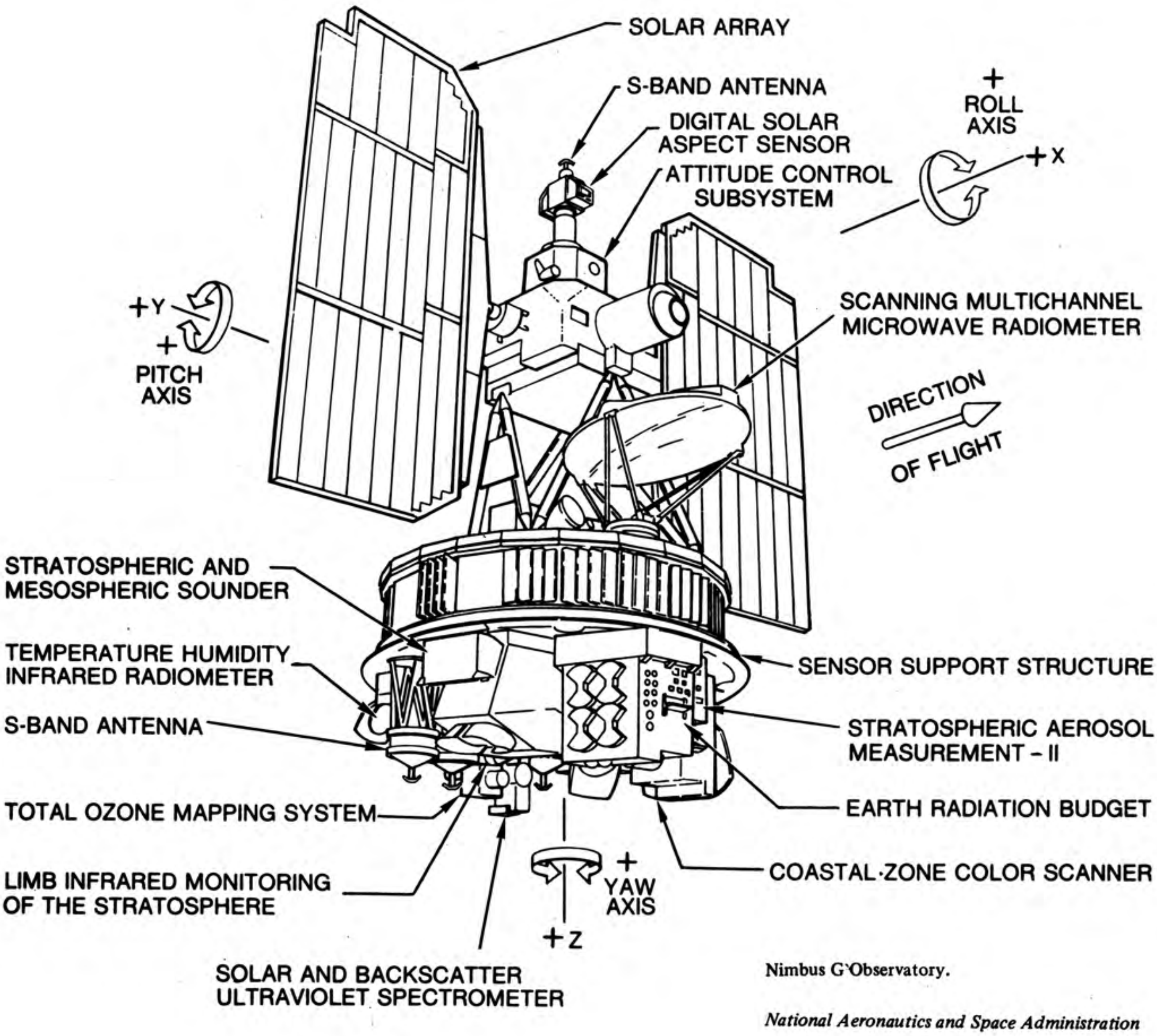
One of eight experiments carried by Nimbus 7 (formerly Nimbus-G), the new NASA observatory satellite, was designed and built in Britain. The experiment, called SAMS (stratospheric and mesopheric sounder), is the fourth and largest experiment designed by Professor J. T. Houghton's group at the Department of Atmospheric Physics, Oxford University, to be carried in a NASA satellite. The seven other experiments in Nimbus 7 have been designed and built in America.

The Oxford instrument, designed with the assistance of the Science Research Council's Rutherford Laboratory, was built by Hawker Siddeley Dynamics, now part of British Aerospace, and has been financed by SRC which also supported the design and production of interference filters provided by the Applied Physics Department of the University of Reading.

Two of the previous experiments designed by the Oxford group, both of which measure temperature, are still operating continuously on Nimbus 5 and Nimbus 6 after five and three years respectively. Data from these experiments are being used to produce daily maps showing atmospheric temperature over the whole globe at heights between 15 and 90 km.

The Oxford experiment is designed to continue temperature mapping work and to extend this to measurements of the concentrations of gases found only in minute quantities (less than 10 parts per million) in the upper atmosphere.

These gases are important because they control the concentration of ozone, a gas which forms a protective shield around the Earth at a height of about 50 km absorbing solar radiation at wavelengths much shorter than the visible. The energy absorbed is converted to heat, warming the atmosphere and thus affecting the climate at the surface. A secondary, but no less important function of the ozone layer, is in preventing the shortwave solar radiation from reaching the ground for such radiation can be dangerous to all forms of life



Nimbus G Observatory.

National Aeronautics and Space Administration

on the surface. The thickness of the ozone shield is therefore of great practical importance. One of the long-term aims of this research is to find out what controls the thickness of the ozone shield and how to avoid weakening it.

Many of the gases measured by SAMS, for instance nitric oxide and carbon monoxide, are formed in the upper atmosphere through the combined effects of chemical processes and the action of sunlight. They are also transported by large scale atmospheric motions. Measurements from SAMS of the variation of the distribution of these gases with latitude and season will provide important information about the circulation of the upper atmosphere and the ways in which the atmospheric circulations at different levels of the atmosphere are linked together.

Data from the U.K. experiment on Nimbus 7, which orbits the Earth about 14 times a day passing over the equator alternately at local dawn and midnight, are relayed by NASA to Oxford every morning where it is processed on a computer especially set up for the purpose; global maps of all the quantities being monitored are produced less than 24 hours after the observations are made. These data are available to all laboratories interested in the upper atmosphere. Coordinated with data from other instruments on Nimbus 7 it should provide a great deal of new information about the chemistry and dynamics of the ozone region.

Research groups at the National Physical Laboratory (Dr. J. E. Harries), Queen Mary College, London (Professor D. Martin) and the British Antarctic Survey (Dr. W. Piggott), are involved in auxiliary experiments to confirm the validity of the data from the various Nimbus 7 sensors.

FRUSTRATIONS OF 'PROJECT CAMEO'

The aim of Project Cameo (Chemically Active Materials in Orbit) was to release a known quantity of lithium and barium into the upper atmosphere, writes Geoffrey Hugh Lindop. The plan called for the release of barium from four canisters over northern Alaska making a bluish white cloud visible from the Soviet Union, Canada and northwestern parts of the United States; and a single release of lithium over northern Scandinavia making a red cloud visible in the early hours of the morning from Greenland, Scandinavia, Great Britain and other parts of Europe.

The lithium, ionised by the action of sunlight, was planned to be observed by the European GEOS 2 satellite, and the time of release was critical to enable the lithium ions to travel along lines of magnetic flux linking the Delta rocket,carrying the CAMEO canisters, to GEOS which is in a geostationary (or Clarke) orbit.

A Delta rocket also launched Nimbus G a few days after the launch of TIROS N. Prior to the originally planned launch of TIROS N on 15 September 1978, a fault was detected in the onboard computer. A subsequent check also revealed loose solder particles in the on board tape recorder. This was the first time a production line tape recorder had been flown in space as part of NASA's standardization programme to minimise the cost of space flight.

Nimbus G also had a similar tape recorder, and a check revealed that it too had loose solder particles within it. Both tape recorders were returned to the manufacturers and the launch of both TIROS and Nimbus delayed by a month.

This delay prohibited the night-time release of the lithium, since at a time when the Delta rocket would be on the same magnetic flux line with GEOS, the Earth's shadow would eclipse the cloud, and scientists were forced to opt for a day time release.

The news dashed the hopes of 200 amateur astronomers in the United Kingdom alone, who had planned to make photographic and visual observations of the cloud, and their disappointment was shared with Dr. Rees, of University College London, who co-ordinated the network of astronomers in the British Astronomical Association.

Another bitter blow to the CAMEO project came when GEOS 2 developed a fault.

A short circuit between the spacecraft structure and a series of solar cells has impaired the operation of three out of the seven experiments carried on the satellite. It was the three experiments that were involved in the CAMEO project. However, the fault is intermittent and the proportion of lost data is small. In fact some of the lost data can be derived mathematically or from the remaining four experiments which are functioning satisfactorily.

It is hoped to stage the CAMEO project again in two or three years when the Space Shuttle will give the researchers greater flexibility in the release time of the gas.

FIFTH SPACE PROCESSING ROCKET

SPAR V, NASA's fifth Space Processing Applications Rocket, was successfully launched on 11 September from the White Sands Missile Range, New Mexico.

Roger Chassay, manager of the SPAR project at NASA's Marshall Space Flight Center, said the flight went extremely well. The rocket flew for about 15 minutes, reaching a height of around 102.5 miles, and allowed the on-board experiments about four minutes of micro-gravity for processing.

The payload was recovered about 55 to 60 miles downrange in a low mountain area on a gentle slope. There was no external damage to the payload. The four experiments were returned to principal investigators for study and reports.

The SPAR project, managed for NASA by the Marshall Center, is a continuing series of materials processing in space rocket flights. It is part of a larger Materials Processing in Space programme, also managed by Marshall, which seeks to develop space materials science and technology in research and manufacturing activities which it is hoped will lead to future space commercialisation by private enterprise.

DUTY FREE FLIGHT TO VENUS

NASA's Ames Research Center received a $12,000 refund of import duty paid for the diamond window aboard its Pioneer/Venus Multiprobe spacecraft – because the window isn't in the country anymore. It was on its way to Venus.

The diamond window, imported from Holland, was aboard one of the five Venus atmosphere entry craft, into which the Multiprobe split 19 days before its arrival at the cloud-shrouded planet.

The window was part of the Sounder Probe, largest of the Pioneer probes. The Sounder Probe reached the planet's surface on 9 December.

Customs regulations allow a refund of import duty, paid for the components of products which are subsequently shipped out of the country.

The Sounder atmosphere entry craft carried six infrared radiometer detectors. These "looked out" through the diamond port hole to measure the heat of Venus' atmosphere. The diamond window, about the size of a quarter, was made of industrial grade diamond. It was required because only diamond is tough enough to withstand Venus' searing atmosphere (hotter than the melting point of zinc at the surface) and still let through the proper infrared wavelengths.

'MOON DUST' SPACE STRUCTURES

"Let's get the docking port ready. Here comes another shipment from the Moon!" The words could be those of a worker in a manufacturing plant floating in space. The shipment could be lunar materials such as silicon, silica, aluminium, iron, calcium, magnesium, titanium, oxygen and slag.

Materials available in abundance on the Moon are being considered for use in building the kind of huge structure in space necessary for future space industrialization. Past studies have indicated that there may be many economic and environmental advantage to using these materials for large future space systems now on the drawing boards.

Such large space structures would require tremendous quantities of materials. One satellite power system structure, for example, would cover a 30-square-mile (77.7 km^2) area in space and a large number of these systems would be required to furnish power for many cities and towns.

The use of materials mined and pre-processed on the Moon, then refined and manufactured in space, would reduce requirements for ferrying large quantities of material from Earth to space with the inherent major transportation costs. It would also reduce a potential environmental impact of large numbers of heavy-lift launch vehicles passing through the Earth's atmosphere.

NASA's Marshall Space Flight Center has awarded a $65,000 contract to Massachusetts Institute of Technology, Cambridge, Massachusetts, for a seven-month study to investigate whether the potential economic and environmental advantages of large space system material delivery and construction from extraterrestrial sources indicated by earlier studies could realistically be achieved. Prof. Rene H. Miller of MIT is the principal investigator.

The study will assume that materials have been mined and pre-processed on the lunar surface and will cover final processing in space to commercial grade materials as required for manufacturing. It will also explore manufacturing processes required to produce large space system components and elements.

SPACE BABY?

The incubation of a Japanese quail's eggs in an Earth satellite would "allow us to trace all or nearly all the stages of development of the first living creature to develop under conditions of weightlessness," Professor Nikolai Gurovsky, head of the space medicine board of the USSR Ministry of Health, said in a recent interview with the newspaper *Literaturnaya Gazeta.*

He was commenting on studies which are being planned in the Soviet Union on the development of a living organism in outer space.

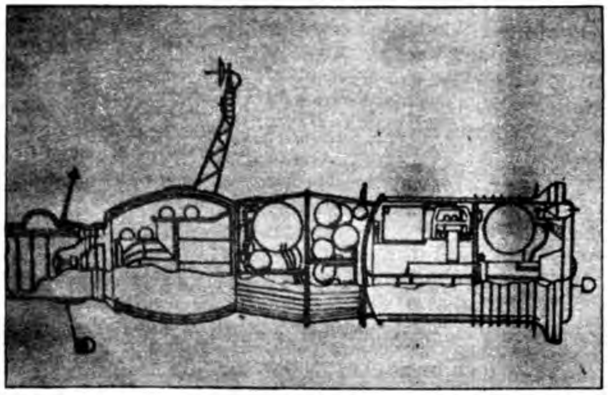
What made the Japanese quail interesting to study was also the fact that it was a serious "candidate" for a place in the closed ecological system of the spacecraft of the future, because really protracted space flights would be impossible unless a "micro-Earth" could be created in the spacecraft providing for the restoration of the atmosphere, the utilisation of wastes and the renewal of food resources for the crew, he pointed out.

Professor Gurovsky said that recent reports in the Western press, which claimed that an experiment was being prepared in the USSR involving the birth of a human being in outer space, were 'many, many years ahead of actuality."

He did not rule out the possibility of a human baby being born in outer space in the fairly remote future. However, before space flights lasting nine or ten months – the duration required – could become a reality, many problems connected with the effects of weightlessness on the human organism remained to be solved.

THE PROGRESS AUTOMATIC CARGO TRANSPORT SPACECRAFT

Details of the structure and payload of the 'Progress 1' cargo transport spacecraft are depicted in this Soviet drawing of the new vehicle. This latest addition to the space fleet of the USSR has a total length, with the docking probe,of 10.8 m. Maximum diameter of the vehicle is 3.7 m, writes Neville Kidger.



The vehicle has three compartments, or modules, and is based for its design on the manned Soyuz spacecraft. The first of the compartments (left in drawing), which is similar to the Soyuz work, or orbital, module is called the cargo, or freight compartment. It is 3.2 m in length with a maximum diameter of 2.6 m. The second module, called the unit module, replaces the recoverable Soyuz descent module with a non-recoverable compartment housing tanks of fuel, oxidizer, air, etc. These supplies are used to 'top-up' those on the orbital station Salyut 6. The length of this compartment is 2.6 m, maximum diameter 3.16 m, minimum diameter 2.6 m.

The third portion of the spacecraft is the service, or aggregate, module. This is a lengthened version of the standard Soyuz service module; the extra length is associated with the avionics packages added for its automatic search and docking role. The length of the service module is 4.8 m (including the standard Soyuz engine assembly). Of this length 2.1 m is the compartment containing the engines, fuel tanks and the associated plumbing etc.; the portion of the service module containing the batteries and avionics is 2.7 m in length. The minimum diameter of the module is 2.8 m and the maximum diameter, 3.7 m is over the rear of the compartment which provides the launch vehicle/spacecraft interface and attachment points. The launch vehicle for the Progress series of spacecraft is a modification of the basic A-2 (SEMYORKA) launch vehicle, Soyuz variant.

Weight of the first Progress transport ship was announced as being 7020 kg, of which 2300 kg was cargo; 1000 kg fuel and 1300 kg dry cargoes, food, linen, etc. The weight and payload distribution of the second Progress craft was slightly different as only 600 kg of fuel was carried on that flight. Progress 3 carried only dry cargoes and air and water so its weight, if it is ever announced, is likely to differ substantially from that of the first two.

The drawing also shows that Salyut connecting tunnel and the Progress/Salyut fuel pipe interface.

SOYUZ 31 REDOCKS WITH SALYUT 6

On 7 September 1978 the Soviet spacecraft Soyuz 31 be-

came the first spacecraft ever to be docked with two separate docking assemblies on the same orbital station. In 1973 the first Apollo spacecraft to visit the Skylab station docked twice with one of the station's two docking assemblies. The capability to redock a Soyuz spacecraft has never been proven before and with the achievement new questions must be asked about the Soyuz spacecraft after the flight of Soyuz 27 which had the appearance of being dedicated to remove the Soyuz 26 spacecraft from the rear docking unit of the Salyut 6 station to free the unit for the first Progress automatic tanker spacecraft which refuelled the station earlier last year, writes Neville Kidger.

Soyuz 31 launched on 26 August carried to Salyut 6 the third Interkosmos crew comprising – Soviet commander Valeri Bykovsky and GDR research cosmonaut Sigmund Jähn. The Interkosmos crew docked the Soyuz 31 spacecraft with the Salyut 6 orbital station on 27 August and spent a total of seven days aboard the station with the resident crew of the Salyut, Vladimir Kovalenok and Aleksander Ivanchenkov, who had docked their Soyuz 29 spacecraft with the station on 17 June. The Soyuz 29 occupied the front docking port of the Salyut 6 station and the Soyuz 31 the rear docking port. Shortly after their docking with Salyut 6 the *Tass* news agency reported that the Interkosmos crew would return home not in their own craft but in Soyuz 29. The reason for this was that the Soyuz 29 systems were considered doubtful for a stay in space of longer than 80-85 days. "Each craft and the systems installed in it have their own definite lifetime for work," Yuri G. Teplakov told listeners to Radio Moscow's home service on 2 September. He continued by saying that the cosmonauts were exchanging their craft "so that the fresher craft remains behind."

To return in the Soyuz 29 spacecraft, the Soyuz 31 cosmonauts had to transfer their shaped armchairs, specially moulded for the individual cosmonaut to allow him to endure the g-loads that occur throughout the descent. They also transferred the centring weights. These are located under the armchairs and are specially calculated in relation to the weight of the cosmonauts and the equipment that has to be transferred. Misalignment of these weights may lead to gross errors at the touchdown aim point, Teplakov said. Following the undocking of Soyuz 29 from Salyut 6 at 1123.18 (Moscow time) on 3 September and its landing at 1440 (MT) – one revolution earlier than previous Soyuz craft – the Soyuz 29 cosmonauts began to prepare for the redocking operation.

Viktor Blagov, deputy flight director of the Salyut 6 programme, told GDR pressmen that the operation of redocking Soyuz 31 with the Salyut 6 front docking port would take three to four days. First, over two days, Kovalenok and Ivanchenkov would partially isolate Salyut 6; they would then enter Soyuz 31. The spacecraft would then be undocked and follow Salyut 6 at a distance of 100-200 m. Salyut 6 would then make a "half somersault" forward, thus turning its nose towards Soyuz 31. Ground control would orientate Salyut 6 and Soyuz 31 and bring them closer together. After completion of the docking, the two cosmonauts would return to Salyut 6. The process of undocking and redocking would take about 90 minutes i.e. within one orbit of the Earth.

Blagov emphasised that there was no rush to perform the task but it was necessary because the rear docking unit of Salyut 6 had to be prepared for the next Progress cargo ship. Only the rear berth of the Salyut 6 station had facilities for refuelling operations.

The cosmonauts prepared for the redocking on 7 September by checking the systems of the two-spacecraft complex and completed some technical documentation, carrying out some work with "biological aparatus." *Tass* then reported that Kovalenok and Ivanchenkov "had transferred to Soyuz 31 at 1353 (MT)." The *Novosti* press agency reports this time as the actual undocking time. Prior to this the cosmonauts had put the Salyut 6/Soyuz 31 complex into a gravitational stabilisation regime" with all of the manoeuvring engines switched off. The station then floated like "a cork" in the Earth's gravitational field, its narrow transfer tunnel pointing towards the planet's centre. Thus the station had achieved, without the aid of automatic devices, half of the 180° "half-somersault" required for the redocking manoeuvre. This "gravitational stabilization regime" was a surprise to Soviet ballistic experts who had anticipated having to use extremely large amounts of fuel to stop the station rolling about in the Earth's gravity field. The station and the docked Soyuz spacecraft have generally assumed an attitude in the gravity stabilized mode of pointing towards the Earth's centre with the docking port at which the Soyuz was docked furthest from the Earth. During the Soyuz 26 (TAYMYR) flight, i.e. crew Romanenko and Grechko, an un-named expert from the FCC said that the station had taken up a somewhat unusual position in space in relation to the Earth. "The essence of gravitational stabilization is that the station, without using any sources of energy whatsoever – in this case the engine and orientation system – orients itself in space permanently towards the Earth." The Soyuz 26 craft was at this time attached to the front docking port of the Salyut.

The cosmonauts had 40 minutes to undock from the station and to berth with it from the other side, according to deputy flight director Viktor Blagov. The undocking was accomplished over the southern Atlantic Ocean, somewhere over the Gulf of Guinea. The cosmonauts then backed off the Soyuz to an unspecified distance and watched (a procedure also well observed on the B/W TV pictures released later) as the station, its motors having been fired, literally for seconds, according to FCC, turned the remaining 90° to assume the, by now familiar, end-on view with the forward docking port facing the Soyuz. "*Aviation Week and Space Technology* reported that the Soyuz approach was controlled from the FCC. The Soviets said that the "mutual approach and search systems were activated at the time planned." The systems of the Soyuz and Salyut functioned reliably at all stages of the redocking, the Soviets said.

Over the standard Soyuz docking zone northeast of Lake Balkhash in Siberia the Soyuz 31 and Salyut 6 spacecraft docked for the second time in just under a fortnight. "We're touching. It's holding!" the two cosmonauts called out. They then checked the rigidity of the seal and the airtightness before equalising pressures between the two craft. The two happy cosmonauts then entered the Salyut for the second time in the long duration flight to continue their wide-ranging scientific, technical and medical experiments.

REMOTE SENSING FROM SALYUT 6

The Soviet Union has doubled its use of space applications data in the management of its economy over the past year. Much of this new data involves imagery from the GDR-made MKF-6M multi-spectral camera facility located on the Salyut 6 orbital scientific laboratory, writes Neville Kidger. Only about 10% of the imagery from the Salyut 6-based camera is used for scientific research, the remainder of the data being channelled directly to the various user agencies.

These agencies are also using U.S. Landsat data in addition to the imagery from the Salyut 4 space station and the series of Meteor weather satellites to study specific areas such as the Caspian depression, to search for characteristic geological structures applicable to the discovery of petroleum and natural gas deposits.

Soviet announcements indicate that mineral deposits explored from space are proving to be especially useful and effective. In a talk broadcast on Radio Moscow's service to

North America Yuri Kolysov described the uses of the data. Siberia, he said, produces a quarter of the USSR's oil and one third of its solid fuels as well as a tenth of its natural gas. "A large number of natural resources are also located there," Kolysov said. These are helping to spur the development of the machine building, chemical and mining industries. However, geologists maintain that a major portion of the mineral wealth of Siberia remains untapped and space photography is aiding in the exploration of these new mineral resources.

Imagery from Earth-orbital spacecraft have furnished geologists with an entirely new picture of the Earth's geological structure. For example, Kolysov states, giant cracks and faults in the Earth's crust are clearly visible from space and geologists have long known these to be where the best mineral deposits were. Location of faults from ground level is usually hampered by covering rock strata and vegetation. From Earth-orbiting space stations the faults are clearly traced. Following studies of the Salyut 4 imagery of the River Ob region in western Siberia the Soviets located an oil field between two parallel fault lines quite close together. At the intersection of similar faults metallic ore and coal strikes have been made.

Geologists, having identified geological faults from space photos, are working in several regions of Siberia and the Far Eastern Regions, saving time and money on fruitless ground-based studies of unprofitable areas. The Soviets have claimed that one photograph of the Earth from space can save many months of work for specialists who have had to use aircraft and ground surveys to study the areas. These time saving photographs also have saved the USSR billions of Roubles and have aided their development programme of utilising natural resources and energy.

Initially imagery of the ground from space was made from two separate points in space creating a "serial" picture. Use of the MKF-6M camera, with its ground resolution of 20 m and its six spectral bands, allows new types of "serial" photographs to be made, thus making possible more accurate assessments and forecasts. Present studies of this nature are concentrating on the route of the 3500 km long Baikal-Amur railroad, which is to cross Eastern Siberia and the Far Eastern Regions. Photography of these areas has singled out areas of seismic activity. These findings have been taken into account when planning various engineering structures such as bridges and tunnels. The pictures have also helped arrive at a more accurate assessment of water resources and possible mineral deposits in the area. Long-term orbital stations of the Salyut type hold out great promise for the future for the use of specialists in various scientific disciplines such as geologists. Constant crew rotations during the flight means that films can be bought back to the Earth fairly quickly. After the film has been processed on Earth a geologist can ask a cosmonaut on the station to obtain additional pictures of a specific area to clear up this or that point.

Also of tremendous benefit to the specialists on the ground are the visual observations of the Earth's surface and the World Ocean (Pacific Ocean) by the cosmonauts aboard the Sayut 6 space station. The Salyut cosmonauts are directed primarily in their visual observation programme by specialists of the State Nature Centre located for the duration of the flights at the Kalinigrad Flight Control Centre (FCC). According to these specialists the observations of the World Ocean is particularly useful as only 5% of it has been studied in detail and any observations of it, especially when it is the result of prolonged and constant observation, is very important.

FCC constantly has asked the cosmonauts to observe the changes in the circulation of the currents in the area of the southern islands. Scientists are very interested in evaluating the colour of various parts of the ocean. The station carries a special colour table and the cosmonauts, reporting from space on their observations, now and then refer to this table. This allows for a more objective assessment of the degree of information gathered. By assessing the shade of colour scientists can draw conclusions on plankton and seaweed distribution and can predict the fishery yields of various parts of the ocean. The cosmonauts have reported the furthest distribution of plankton, making it possible to determine the most probable locations of fish shoals.

Recently FCC asked the cosmonauts for observations of icebergs in the southern hemisphere. Very quickly the "Photons" (i.e., Kovalenok and Ivenchenkov) reported which icebergs they had observed and where they were located. The cosmonauts reported that they could easily distinguish an old, disintegrating iceberg from a solid one that has not been in the sea for long. A halo of fresh water round the old, melting iceberg can be observed from space, they said.

The cosmonauts also reported being able to see a difference in the ocean's surface level. They reported that sometimes a series of steps, as it were, could be observed. The currents in those places are particularly strong. Specialists have confirmed the possibility of such phenomena. However, they are observed only rarely, and therefore the space observations were of particular interest.

The visual observation programme of the Salyut 6 cosmonauts is also being used to compile an atlas of the world's snow and ice resources; this would be valuable in finding new sources of fresh water. Earlier observations from the Salyut 6 space station have disclosed the existence of huge water deposits in the Mangushlak peninsula, totalling 3,5-4 billion gallons.

OTS 2 GOING WELL

The European Space Agency's satellite OTS 2 has successfully completed its first tests of the transmission of television programmes beyond continental Europe. The experiment was carried out on the occasion of the conference on "The Role of Space Technology for Development" in Cairo from 7-12 October 1978, sponsored by the Egyptian Academy for Scientific Research and Technology.

The demonstration involved transmitting television signals from the British Post Office's station at Goonhilly Downs (England) *via* OTS 2 to a transportable receiving station set up in Cairo. Nearly eight hours of BBC1 television programmes were directly transmitted from Britain to Egypt, at a rate of about 1½ hours per day. The transportable station was developed by Ferranti Microwave Division of Ferranti Electronics Limited, in association with the U.K. Department of Industry.

After five months of preliminary tests, the communications test programme using the OTS 2 satellite, which is planned to last at least three years, has now reached an operational tempo.

This programme, which has been undertaken by ESA and the Interim Eutelsat organisation*, is designed to prepare the European P&T administrations for the subsequent exploitation of the operational European Communications Satellites (ECS), which will come into service from 1981 onwards. It includes two kinds of experiments: telephone and television routing tests with the aid of large Earth stations using antennae of 15 to 19 m diameter (Fucino, Italy; Bercenay-en-Othe, France; Goonhilly Downs, England; Usingen, West Germany and Barcelona, Spain); and propagation experiments together with experiments relating to new applications for which much simpler terminals will be used. Some 50 institutes, universities and telecommunications entities will take part in the second category of tests using more than 30 small terminals, most of which have antennae of approximately 3 m.

* *The Interim Eutelsat organisation groups the European users that are members of the European Conference of Postal and Telecommunications Administrations (CEPT).*

1928-1929 FORERUNNERS OF THE SHUTTLE: THE 'VON OPEL FLIGHTS'

By Frank H. Winter*

Introduction

On 11 June 1928, the tiny, cramped tailless sweptwing sailplane named *Ente* ('Duck') with veteran glider instructor Fritz Stamer in the cockpit leapt from Germany's Wasserkuppe mountains under the thrust of a pair of solid propellant rockets and travelled just over three quarters of a mile in about sixty seconds. The designers of the little 'Duck' believed that this modest feat was but the first stage in their own concept of a space shuttle. They envisioned, firstly, terrestrially-bound rocket planes for either delivering passengers or mail from one continent to another in record time; then, after the perfection of propulsion and life-support systems, true spaceships capable of navigating to other worlds. Their funds and science were not as grand as their visions. The little craft and others like it saw a brief but spectacular vogue until they disappeared both from the skys and the Sunday supplements. Nonetheless, the story of this dedicated group of enthusiasts has never been adequately told.

If we discount the fantastic claims of the possibly legendary Chinese official Wan Hu, who is said to have lost his life in an attempt to propel himself by a kite-borne rocket chair in ca. 1500 A.D., and the story of a 1623 manned winged rocket flight by the Turk, Legari Hasan Tchelbi, who wished "to have a talk with the Prophet Jesus," we can safely assume that the first bonafide rocket plane flew in Germany in 1928. It grew out of Fritz von Opel's rocket car stunts.

The idea also took shape in the mind of Antonius Raab, the 32 year old partner of the Raab-Katzenstein-Flugzeugwerk, GmbH, the aeroplane builders of Kassel, in the Spring of 1928. He was determined to fly the machine himself. On 29 April a contract was drawn up between the Opel Automobile Company of Russelsheim and the Raab-Katzenstein Flying Machine Works of Kassel "for the application of the 'rocket' principle to aircraft." Raab, with his partner Diploma Engineer Kurt Katzenstein would apply to their lightest aeroplane the solid-propellant Sander rockets that had proven themselves so well in Fritz von Opel's rocket cars. This machine was the 22 ft. 6 in. (6.85 metres) long, 552 lb. (1,214 kg) Raab-Katzenstein R.K. 9 *Grasmücke* ('Warbler'). The two-seat cantilever biplane with a 29 ft. 5 in. (8.96 metre) span, was normally powered by one 40 h.p. Salmson radial engine fed by 42 litres (9 gallons) of fuel from a tank in the top wing. In its new role, the engine, the tank, and some anciliary equipment would be stripped out to accommodate the rockets and lighten the plane as much as possible.

Two batteries of Sander rockets of unspecified thrust and number were to be fitted on each side of the fuselage between the wings, with electrical ignition from the cockpit, and cross-bracing and welded steel-tube structure of the R.K. 9 were to be specially strengthened "to withstand the high speed expected to be attained." Following Raab's consultations with his "scientific advisor," meteorologist Professor Ludwig Weickmann, Director of the Geophysical Institute at Leipzig University, both the pilot and the plane were to be equipped with parachutes and meteorological instruments also to be taken aboard. The latter included wind-temperature gauges, wind speed and pressure indicators manufactured to order by the famous Zeiss scientific instrument-makers of Jena. Should Raab find himself unable to breath or unable to withstand the cold during the climb towards the estimated maximum altitude of 32,800 ft. (10,000 metres) on the first run, he would bail out leaving


Die Rakete

Zeitschrift des Vereins für Raumschiffahrt E. V.

Das erste bemannte Raketenflugzeug.

Segelflugzeug „Ente" der Rhön-Rossittengesellschaft.

Nr. 7. Breslau, 15. Juli 1928 2. Jahrg.

Title page of *Die Rakete* 15 July 1928 depicting the flight of the rocketpropelled glider *Ente*.

Photo: F. I. Ordway Collection

FRITZ STAMER (1897-1969), believed to have been the world's first pilot of a rocket-propelled plane. He flew the *Ente* glider (above) from the Wasserkuppe Mountains, Germany, on 11 June 1928.

The Smithsonian Institution

* *Research Historian, Astronautics, National Air & Space Museum, Washington, D.C.*

the Grasmücke to continue until its fuel was exhausted. Shuttle-like,the Grasmücke was to glide gently back to Earth.

The initial flight or flights were to be made with the small Salmson engine. If Raab confirmed the theory expressed by Weickmann and his colleagues that neither fogs nor storms are found above 8,000 metres (26,248 ft.), then the question of a regular trans-Atlantic air service by rocket plane (it was believed) would be practically solved.

Professor Weickmann, who later co-edited an account of the 1931 Polar voyage of the *Graf Zeppelin* in which he participated, also held the theory that the Earth is surrounded by a stream of ozone and that the temperature there is about like that on the Earth's surface instead of being unbearably cold. He based his theories on tests made with sound waves, a kind of pre-radar scan of the upper atmosphere. While much hope was thus entertained upon the success and findings of the Grasmücke flights, the practicalities were still essentially Earth-based. Even the most sanguine believed that a "journey into space beyond the atmosphere is still far in the future."

Rocket propulsive methods were crude, and von Opel shopped around to four or five of Germany's leading pyrotechnicists before engaging the services of Friedrich Wilhelm Sander. Sander was the genial, rotund general manager of the old Cordes firm at Wesermünde, near the port of Bremen, where he supplied ships with his large gunpowder lifesaving rockets and rocket signals as Cordes had been doing for 60 years.

A shrewed businessman, von Opel arranged a lucrative partnership between himself and Sander so that both would profit. Probably in his mind, though never overtly expressed, was the enormous amount of publicity he would reap upon himself and his Opel Car Company. He signed an exclusive contract with Sander. The "research" was to be paid partly out of his own pocket and partly by his company. Von Opel also built for Cordes a special hydraulic rocket press. In return for these considerations the motor magnate had the option of buying Cordes' majority.

The research programme was outlined as follows: ground vehicles with rockets, model airplanes with rockets, and manned aircraft with rocket propulsion. Then came the development of liquid-fuel systems, likewise applied to manned flights. The third party in this contract was Max Valier, then one of the world's leading exponents of rocketry and space travel. The agreement was consummated on 8 December 1927.

In large measure, this ambitious programme was actually carried out – including the liquids. Typical solid fuel Sander steel-cased rockets for von Opel's projects were 650 mm (26 in.) long minus the 150 mm (5.9 in.) long nozzle. Outside diameters were 125 mm (5 in.) and 70 mm (2.7 in.) at the flare of the nozzle. Other models were also available.

There were two basic types: rockets with bored charges, or conical cavities called "seelen," or souls, and end-burning grains like cigarettes and called "branders." The former possessed greater burning area about the orfice and therefore produced greater thrusts for shorter periods of time. The seelen rockets thus served as boosters and the branders as steadier, long-duration, low thrust sustainers. A wide variety of performances were available, typical figures for the boosters being 180 kg (396 lb.)/3 seconds and 20 kg (44 lb.)/30 seconds for the sustainers. An average rocket weighed about 6 kg (13.2 lb.), 4 kg (8.8 lb.) of which consisted of the powder. By "mixing" the batteries or clusters of these rockets, the experimenters hoped to achieve something approaching controlled thrust – boost phases for fast starts and get-aways followed by lower but steadier impulses for sustained performance.

This technique was fully proven in a spectacular run of von Opel's Rak III car on the Avus Speedway near Berlin on 23 May 1928 before an invited crowd of 2,000 including high government officials and ranking members of the Reichwehr (the Army) and Navy. Von Opel himself had been at the wheel, a fitting image of the man of action and of the future with his goggles and blond hair streaming in the wind. All two dozen rockets worked perfectly, the car reaching a maximum velocity of some 125 mph (201 km/h). Afterwards he spoke to the crowd *via* a public-address system, extolling the vast potential of the rocket. But he was curiously silent about his ongoing rocket plane project with Antonius Raab. Instead, the audience heard prophesies of how the conquest of the stratosphere and of space itself was only a matter of time. Von Opel was saving the spotlight for himself.

While awaiting the much promised flight of Raab's Grasmücke, the world air-minded public was confronted with suspense enough, with the saga of Umberto Nobile's flight of the 'Italia' dirigible over the North Pole. The airwoman, Amelia Earhart, was reported to be preparing for her Atlantic crossing. As for Raab's intended feat, the German, American, and presumably other papers published occasional reports but they were neither clear nor consistent. The *New York Times* for 4 May 1928, for example, announced that the flight day would be within three weeks, "probably immediately after Whitsunday." Three batteries of rockets were to be installed, the story went on, two under the wings for "an almost vertical ascent" and a third battery in the rear for level flight. The *Times* and the *Berliner Morgenpost* for 6 May moved up the schedule to two weeks and also revealed the original planned launching site as the Leipzig-Mockau flying field. The place was changed, the papers said, because the field near Berlin offered better facilities. The *Times* for 25 May and the *Morgenpost* for 26 May now said the flight would be in the middle of June. Von Opel, Valier, Sander, and "a commission of experts" were expected to visit the Raab-Katzenstein works at Kassel within ten days to examine the machine prior to lift-off. The 8 June edition of the *Times* introduced an entirely new configuration. The tailess duck-shaped *Ente* gave way to the biplane canard. The maiden trip also had an expanded route from Berlin to Paris and propulsion was to be derived by short spurts from a conventional reciprocating engine, presumably assisted in flight by the rockets. If everything went well the rockets would fully supersede the piston motor. Garbled as they were, these stories contained elements of both fact and fiction.

When the *Berliner Tageblatt*, the *Morgen Post* and other papers around the globe finally reported the flight, the man at the helm was not Antonius Raab but Fritz Stamer. What had happened? This fifty year old puzzle has been only partly solved by a follow-up item in the *Times* of 16 June 1928, *The Times* of London for 19 June and other newspapers. Stories were datelined to at least 15 June. They told of a rift between von Opel and Raab. It was a "row" that lead to von Opel's cancellation of his contract with Raab and a law suit for recovering damages reportedly amounting to several hundred thousand marks. Von Opel accused Raab of violating the agreement by unauthorizedly leaking plans to the press. Von Opel also stated that the Raab-Katzenstein airplane "of the duck type" was unstable and incapable of high speed. Raab denied these accusations, declaring that he would continue his own experiments "without Herr Opel and I will make the first flight in a fortnight" [1]. In fact this was the last public mention of Antonius Raab's rocket machine. Willy Ley, in his *Rockets, Missiles, and Space Travel*, alludes to some supposed later experiments and adds that they were discontinued because "the Army intervened." We have found no other source to corroborate this account.

Always conscious of the power of the Press and eager to insure the permanent entry of his own name into both

aeronautical and automotive history, von Opel has left us only with a one-sided and cloudy view of what really happened. With his death in 1971 we must turn to other sources.

Such papers as Sander may have had were probably seized by the Gestapo upon his arrest in 1934 when he was accused of treasonably selling his *lifesaving* rockets to the Italians [2]. For his part, Valier remained diplomatically silent. In his *Raketenfahrt* (1930), he briefly dismisses the entire affair, saying cryptically that: "At the beginning of May there entered an unexpected development, a temporary partnership with the Raab-Katzenstein Works, in which an Ente-type 'Grasmücke' was to be modified into a rocket plane. Finally, there was a separation of the author [Valier] with von Opel and Sander and at the beginning of June the experiments were transferred to the Wasserkuppe, not to Kassel." Of Valier's own falling out with von Opel, the science fiction writer Otto Willi Gail, who knew them both well, says that after the Rak III car run of 23 May and excited private discussions about rocket planes, Valier came into heated disagreement with von Opel over their approaches. "These differences were basically insignificant," Gail observed, "but obstinancy on both sides made every attempt at settlement hopeless." The headstrong von Opel, still in union with the unflappable and faithful Sander, thus pursued his own course. He was to have his way. As for the rocketry "career" of Antonius Raab, like a meteor it flickered out almost as soon as it had appeared. The Raab-Katzenstein Works, by mergings and purchases, became the Gerhard Fiesler Werke GmbH that produced the infamous V-1 and other missiles of World War II. Raab himself conducted his aircraft business in several places. The German aeronautical journals reported his presence in Finland, then in Tallin, Estonia, then Athens, and so on. Otherwise, the would-be first rocket pilot in the world who once astonishingly proved the manoeuvrability of his light planes by landing one in downtown Berlin on Unter den Linden, never again became engaged with rocket aircraft [3].

Other missing pieces of the story are supplied by the protagonists themselves. Enter Dr. Alexander M. Lippisch, a brilliant young aerodynamicist. His favourite swept-wing delta configuration was to streak through German skies during World War II as the first all-rocket fighter Me-163.

In late 1925, when he was 31, Lippisch had been put in charge of the technical department for aerodynamic research and glider design at the Forschungsinstitut (Research Institute) of the Rhön-Rossitten-Gesellschaft (RRG) on the Wasserkuppe in the Rhön Mountains of Thuringen, southeast of Kassel. Together with the chief gliding instructor Fritz Stamer, Lippisch gained invaluable experience designing ever advanced shapes and having them test flown as gliders.

From at least 1927 both Lippisch and Stamer began to collaborate on booklets teaching the construction of flight models and gliding for beginners. These works became classics of their field, one of them being translated into Spanish in 1941 and several others into English. Lippisch's partnership with Stamer became permanently sealed, as it were, when in 1926 he married Kate, Fritz's sister. By 1928 Lippisch completed his experimental tail-first planes the *Storch* ('Stork') and *Ente* ('Duck') which "by chance," in his own words, "were to provide my first contact with rocket propulsion." Historically, however, the tail-first design did not originate with Lippisch. It may be found long before World War I, notably in the designs of the Englishman Lieutenant John W. Dunne of the Royal Engineers [4].

In May, 1928, Lippisch recalled – unfortunately we do not have the exact date to place it in context with von Opel's 23 May rocket automobile run and his falling out with Antonius Raab – he (Lippisch) was visited at the Wasserkuppe by two men eagerly looking for a tailess airplane suitable for testing a "new type of engine." These gentlemen, Lippisch later learned, were Fritz von Opel and Friedrich Stamer. "I showed them the *Storch* and the *Ente*, and when Fritz Stamer and I eventually found out that they were *really* interested in rocket propulsion, we promptly proposed the use of the *Ente* since this aircraft had good longitudinal stability and control, and we suspected that the rocket thrust would affect the longitudinal stability. However, when Opel and Sander again visited the Wasserkuppe in the following month, we first tried models of the Storch with Alexander (*sic*) Sander's powder rocket between the wings, launching the 'boosted glider' from short wooden rails." Perhaps Antonius Raab really did begin to progress from the cantilever Grasmücke biplane with its inherent drag and stability problems to the tailess pattern. Nikolai A. Rynin, the Soviet astronautical encyclopaedist and "clearing house" for the astronautical and rocketry literature of the world at that time, wrote in Volume IV of his famous *Interplanetary Flight* encyclopaedia (published in 1929) that the Grasmücke was being converted into "a 'Canary' with elevator in front, and installation of the rockets was proposed at the rear." Indeed, a drawing of this arrangement of the Grasmücke is found in the respected German aeronautical journal *Der Flug* for May, 1928 (10 Jahrg., Erstes Maiheft, 1928, p. 164). If there was any truth in this, von Opel still did not find the design satisfactory and desired an entirely new plane. One of the principal features of the Lippisch configuration was the elimination of any danger of backburning by the rockets; the Grasmücke was originally to have had a specially protective steel plate in front of its tail and in the general path of the exhaust. The Ente obviated this necessity. Flames from the Sander units reached one metre (3 ft.) from their nozzles. It was the inferior aerodynamics of the ill-chosen Grasmücke which must have upset von Opel most of all.

Hence, the confused newspaper accounts. Unhappy with the design and aggrevated by the distorted reports, von Opel apparently sought out Lippisch in secret to investigate other possibilities and severed his relations with Raab *at his own convenience*.

Fritz von Opel was not a man to linger once he had set his mind on a specific goal. Throughout 9-11 June 1928, he personally financed and witnessed rocket model tests of a scale Storch glider at the Wasserkuppe. The complete, illustrated report by Lippisch and Stamer appears in the *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, 19 Jahrg. 1928, 12 Heft, pp. 270-274. It is, however, incorrect to say that these were the first rocket model tests with the ultimate goal of manned flight. In August, 1903, for example, the prolific German-born inventor of the Berliner helicopter, Emile Berliner, successfully shot off a "flying machine" at Washington, D. C. to 50 ft. (15.2 m) with two 2 lb. (0.9 kg) skyrockets. And in his own quest for suitable motive power for a heavier-than-air flying machine, the Scottish-born creator of the telephone, Alexander Graham Bell, tried out a series of small rocket-propelled model planes, including one with delta wings, in 1892 in Novia Scotia, Canada. To fully internationalize these experiments we also may add the names of the Italian dirigible pioneer, Enrico Forlanini, and the Rumanian man of many inventions, Henri Coanda. About 1885 Forlanini sent his own miniature rocket airplanes along a stretched line to investigate their behaviour at closer range. As a preliminary step towards his supposed "turbopropulseur" jet aircraft of 1910, Henri Coanda also claimed to have resorted to skyrocket-powered model flying machines, in 1907 [5].

Such efforts preclude strictly recreational winged model rockets. These may be traced back to at least the last century and have been thoroughly surveyed in the paper, "A Century of Rocket-Propelled Model Aircraft" by Frank H. Winter, George S. James and Gregory P. Kennedy and presented at the 26th International Astronautical Congress,

Lisbon, 21-27 September 1975.

The von Opel-Sander-Stamer-Lippisch tests were elevated to a full-scale airplane immediately after the model flights ; in effect, this was to be the first manned rocket flight.

The Rhön-Rossitten-Gesellschaft's Ente was brought out. Sander supplied 360 kg (790 lb.)/3 second thrust bored rockets and branders of 20 kg (44 lb.) which burned for 30 seconds. Von Opel had insisted upon this powerful but unpredictable combination but fortunately for the cautious and experienced pilot, Stamer, this foolhardiness was overriden.

Lippisch and Stamer both humorously recount the incident. In his memoirs, *Zwölf Jahre Wasserkuppe* ('Twelve Years on the Wasserkuppe'), published in 1933, Stamer recalled that: "Von Opel had hidden a group of itinerant musicians ("Wandermusikanten"), who happened to be crossing the Wasserkuppe, behind the hangar. As we were setting out to start the proceedings, he himself directed the 'Stamer-Lippisch-12-Kilogram March' to the (funereal) tune of *Immer langsam voran* ("Always Slowly at the Head"). This was then followed by the Opel-360-Kilogram March' to the melody of the 'Radetzky March.' "As might have been expected," Lippisch adds, "the atmosphere became a little tense." But the cautious Stamer-Lippisch team won out. The manned Ente was fitted with the more reasonable 12, 15, and 20 kg (26.4, 33, and 44 lb.) 30 second units (this is contrary to the supposed 25 kg or 55 lb. motors often reported, even by Lippisch). The best accounts of these first flights are found in the official report by Fritz Stamer as his part of the joint article with his brother-in-law Lippisch, "Versuche mit neartigen Flugzeugtypen" ("Experiments with New Airplane Types"), in the *Zeitschrift für Flugtechnik und Motorluftschiffahrt* cited above and in Stamer's more popularly written *Zwölf Jahre* (pp. 96-100). (A shorter Stamer account is also found in *Flugsport*, 20 June 1929, pp. 232-233).

The first starts were failures. The Ente's 12 and a 15 kg rocket were to be ignited electrically one after the other from the cockpit. A built-in override system prevented the rockets from igniting simultaneously. With the initial push provided by the bungy cord the rockets were to have switched on once the plane was free of the rope. Yet when the switch was thrown the thrust was found to be pitifully feeble. "Even the 12 kg rocket could not lift..." For the next attempt the rockets were slightly upgraded to 15 and 20 kg. These too proved inadequate. The plane "could not maintain horizontal flight and it had to land after about 200 metres (656 ft.), without the 20 kg rocket being used." In the third attempt, made with two 20 kg rockets fired in succession automatically, Stamer became not only fully airborne but also successfully, albeit briefly, *rocket propelled*. Quoting from Stamer's official report: "The airplane left the ground very well with the starting cable aided by the rocket. After a straight flight of about 200 metres (656 ft.) during which there was a slight ascent of the machine, I made a curve to the right of about 45° and again flew straight for about 300 metres (984 ft.). Then a curve to the right of about 45° was made again. The first rocket was burned out immediately after this curve and the second rocket was ignited, which immediately made further flight possible. This time I flew about 500 metres (1,640 ft.) in a straight line, then in a 30° curve to the right and after about 200 metres in the new direction the machine was landed on gently rising ground just before the second rocket burned out. The total flight, including all curves, was about 1,300-1,500 metres (4,264-4,920 ft.). The total flying time was 60-80 seconds."

Attempt No. 4 did not fare so well. The Ente was to soar over a higher slope and, as before, it was fitted with two 20 kg thrust Sander cartridges. From Stamer's *Zwölf Jahre*, we have the information that: "The takeoff went without a hitch. The first rocket was burning and I had really become accustomed to the very loud hissing of the jet flame spurting out of the nozzle, when about 3 seconds after ignition there was an ear-splitting explosion... the entire aircraft was burning away merrily, and judging by the violence of the explosion, a few things contributing to its stability must have suffered some damage too. I was particularly concerned about the wing suspension. I decided not to force the burning bird down vertically, although in doing so the flames would be pushed back to the rear, but to let it glide down carefully so as not to break up in the air. I was further comforted by the thought that the second rocket was there behind me in the fire, likely to go off, one way or another, at any moment.

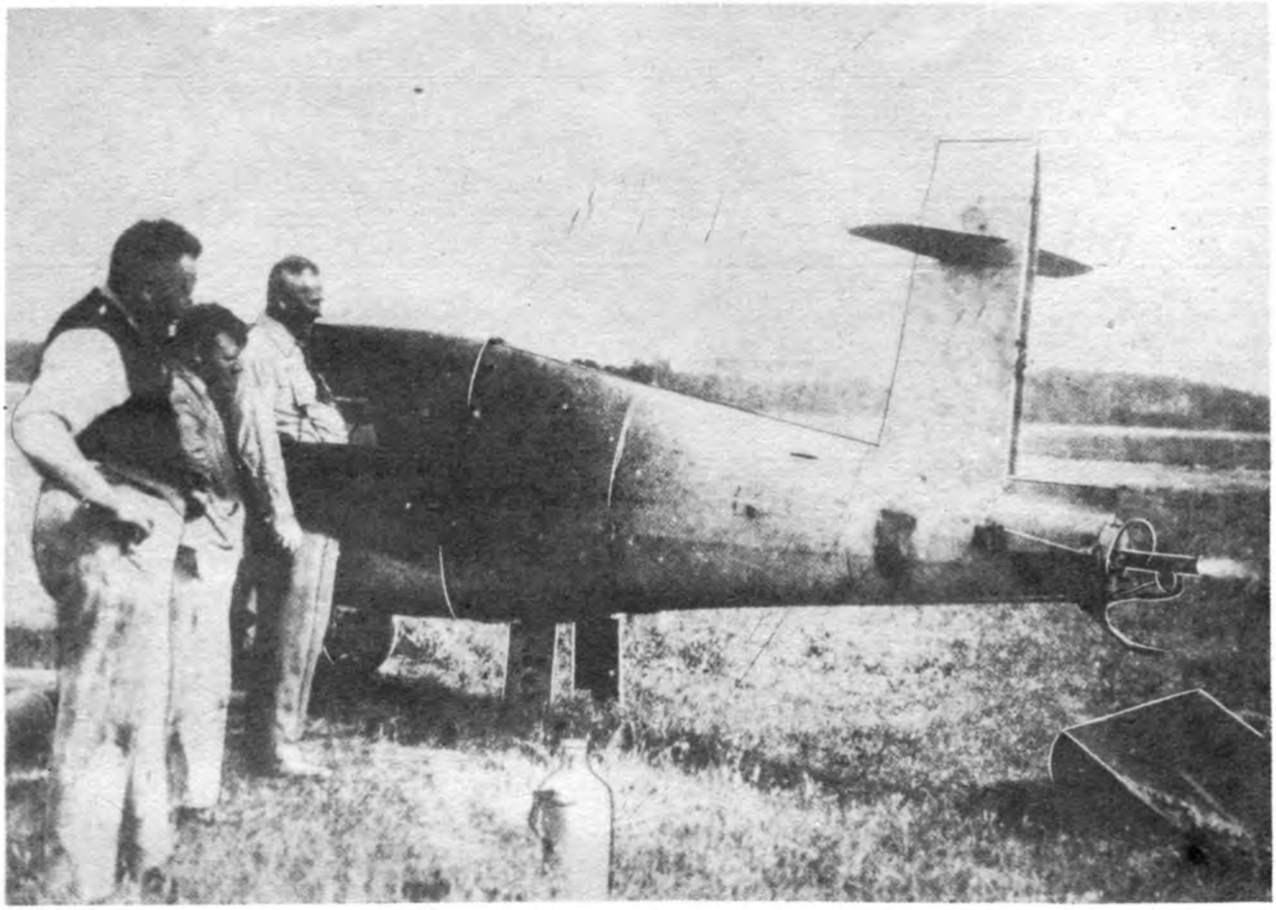
"Moreover, under my seat it was becoming first pleasantly, but then obtrusively warm. Fist-sized chunks of powder from the exploded rocket had come flying in all directions into the machine and had set fire to it. One such chunk was now appropriately situated under the thin plywood seat. At last I grounded the machine. I made the finest landing and thereby possibly coming into closer contact with the second rocket. This was likely to go off at any moment as it was, and things would be in a bad way if I happened to crash right onto it. No sooner had the machine stopped than I had already climbed out of it: I saw the ignition wire burning on the iron rocket casing and I tried to tear it away. But it was already too late. The second rocket ignited, but it fortunately burned out in the proper manner, despite the intense heating of the steel jacket. If it, too, had exploded, my prospects would certainly have not been very bright. Now I wriggled about in the wet grass in order to extinguish and cool my smouldering posterior. After the second rocket had burned out I was then able to extinguish the burning ship with the helpers who had arrived in the meantime. My need to fly with powder rockets was temporarily satisfied..."

Fellow glider pilot Robert Kronfied supplied this postscript: "Herr Stamer went into a dive to extricate himself from the flames, and landed in the nick of time with two large holes burnt in the back of his coat. Thus ended the first attempts to pilot a machine propelled by a rocket. The experiments were carried on in all secrecy, so that the only modest record of Herr Stamer's wonderful feat is his 'Rocket Coat,' which has been preserved in memory of this perilous day" [6].

The flight of the Ente almost cost Stamer's life. The cost to von Opel, in cash, was 1,000 Reichmarks!

Papers picking up the news of the flights, such as the *Berliner Tageblatt* for 13 June 1928 and the *Frankfurter Zeitung* for 14 June 1928, generally confined their coverage only to Stamer's triumph [7]. The near fatal disaster is almost invariably never mentioned. Also unreported were the truly confidential experiments in 1928-1929 with a liquid fuel engine mounted on a tied-down airplane and conducted by Sander and others with von Opel's backing. Surely the liquid rocket-airplane combination was a "first" by any reckoning, even if it did not fly. It was all the more remarkable considering that by this time the liquid rocket was little more than an engineering concept. The press-shy Goddard kept silent upon the details of his own work and his successful 16 March 1926 shot remained unknown until a decade later.

Our knowledge of Sander's and von Opel's liquid-fuel phase comes from three sources: Max Valier's *Raketenfahrt*, from long suppressed revelations made by von Opel himself in a paper presented before the Deutches Museum in Munich on 3 April 1968, and from a hitherto mysterious photograph unearthed in the von Opel archives and published here, probably for the first time. There were in addition, contemporary hints that liquid fuel work was afoot. Von Opel could not contain himself entirely, especially after his own rocket flying experience on 30 September 1929.



This historic picture from the von Opel archives shows the static test of a benzol/nitrogen teroxide liquid propellant rocket engine mounted on a Mueller-Griesheim 1 two-seat high-wing monoplane, 1928, by Friedrich Sander (third man on right), Engineer Schaberger and Fritz von Opel. (Schaberger may be one of the other men shown in the photograph). The rocket developed a steady thrust of about 70 kgf (154 lbf) and was intended by von Opel to power the Mueller-Griesheim plane across the English Channel. There was, according to von Opel, "lack of interest on the part of government and industry" and the project was never realised. The rocket plane, nonetheless, represents the earliest known liquid propellant rocket aircraft, even though it was never flown.

Adam Opel AG, Russelheim, Germany

As far away as Canada, for example, it was reported in the *Canadian Air Review* for December 1929 that: "The rockets in the flight were made of powder, but the German (von Opel) said experiments were going forward on a liquid to propel the plane." In a cabled exclusive to *The New York Times* on 30 September 1929, von Opel is also quoted as saying: "Sander and I now want to transfer the liquid rocket from the laboratory to practical use. With the liquid rocket I hope to be the first man to thus fly across the English Channel. I will not rest until I have accomplished that."

In his speech at the Deutches Museum upon the occasion of the donation of a replica rocket car (a copy of his plane was intended but apparently never built because of space limitations), the immodest von Opel for the first time revealed the name and rôle of another of his co-workers. This was Engineer Schaberger, now identified as Josef Schaberger. "He belonged," von Opel said, "with the same enthusiasm as Sander to our small secret group, one of the tasks of which was to hide all the preparations from my father, because his paternal apprehensions led him to believe that I was cut out for something better than being a rocket researchist. Schaberger supervised all the details involved in construction and assembly (of rocket cars), and every time I sat behind the wheel with a few hundred pounds of explosives in my rear, and made the first contact, I did so with a feeling of total security." Then, after regaling his audience with both the glories and failures of his rocket cars and trains (one of which blew a hapless cat to smitherines), von Opel returned to Engineer Schaberger. "On this occasion," he said, "I would like, for the first time, to reveal what I consider the crowning achievment of our work. As early as 1928, Mr. Schaberger and I developed a liquid rocket, which was definitely the first permanently operating rocket in which the explosive was injected into the combustion chamber and simultaneously cooled using pumps." No matter that Goddard began developing liquid fuel rocket pumps from 1921 (although resorting to pressure-feeding in his 1926 rocket). The claim of "permanently operating" is more justified. "We used benzol as the fuel," von Opel continued, "and nitrogen tetroxide as the oxidizer. This rocket was installed in a Mueller-Griesshheim aircraft and developed a thrust of 70 kg (154 lb.)." Valier says that by May 1929, the *Sander* engine produced a thrust of 200 kg (440 lb.) "for longer than fifteen minutes and in July (1929) he was able to attain powered phases of more than thirty minutes for thrusts of 300 kg (660 lb.) at Opel's works in Rüsselsheim. Moreover, Sander focused his attention to the constancy of performance. By using a by-product of the chemical industry as an oxidant, he succeeded in forcing

down the price per kilogram of fuel mixture to 20 Pfenigs." Whether Schaberger or Stamer was the father of the von Opel liquid rocket remains an open question. Certainly both were very much involved and Valier's description of the fuel fits the hitherto "secret propellant" of benzol and nitrogen tetroxide. Presumably with this same mixture Sander was able to successfully launch a secret 50 kg (110 lb.) thrust liquid fuel rocket on 10 April 1929, and another two days later, according to Valier. To confirm at least part of this, we have an occasional contemporary statement: e.g., *Popular Mechanics* for August 1929 reported that von Opel was constructing "a special ship... at Griesheim, Germany." Far more significantly, we have the photograph (p. 79). It clearly shows the chubby Friedrich Sander cheerfully and calmly standing beside two unidentified men (possibly one of them Schaberger) while a liquid fuel rocket motor blasts away at the rear of a grounded Gebrueder Mueller Griesheim G.M.G. I or II two-seat high-wing light monoplane. This aircraft was manufactured by the brothers Mueller at Griesheim bei Darmstadt from 1927 (see *Jane's All the World's Aircraft* for 1929, p. 176c). If pictures are worth a thousand words then this one gives full value. Sander and the other men stand astonishingly close to the rocket blast, their faces and postures altogether relaxed, indicated indeed that the static test was a very long and stable one. Admittedly, the performance figures quoted by Valier and von Opel are nothing short of phenomenal, especially for 1928-1929. Unfortunately we have no further details, nor do we have additional data on the gifted engineer Schaberger.

Why was the flight of the liquid-powered G.M.G. never carried out? For the answer we must again return to von Opel's revelationary speech on 3 April 1968. In this presentation, entitled, "The Historical Development of Rockets and the Purpose and Limits of Technology," von Opel concludes that "In 1930 I wanted to fly across the English Channel in this craft, but this wish was never realized due to lack of interest on the part of the government and industry, and also because of my (automobile) activities in America. I can only say, thank God, because several famous pilots went down in the same type of aircraft one after another, because of a structural defect." Newspapers of the day confirm this.

By December, 1930, von Opel had completed a busy ten-month study of the manufacturing methods of General Motors at Detroit and Flint, Michigan. While in America with his new bride, he attempted but failed to interest the U.S. Navy in Washington in using solid rockets, "to prevent forced airplane landings."

In the interim, on 30 September 1929, von Opel made his "official" rocket plane flight which is too often claimed as being the first anywhere. Despite his well-earned reputation in the aeronautical world, Fritz Stamer never appears to have been particularly publicity-seeking. He did recount his adventures with rockets but never vigorously refuted von Opel's wide-reaching assertions that he (von Opel) had made the "first human rocket flight." As a postscript to Stamer's personal story, he continued to set national and world gliding records, to write, take out patents, and even to build his own light motor instructing airplane, the Stamer "Hummel" of 1934. One of the co-founders of the German

FRITZ VON OPEL at the controls of the Opel Sander Rak. 1 rocket plane. At left is Fritz Stamer who made the first rocket flight in an *Ente*. In the middle is pyrotechnist Friedrich Sander who supplied the solid propellant rocket motors. Photograph was taken on 30 September 1929 at Frankfurt just before von Opel made his flight.

The Smithsonian Institution

Aero Club and winner of the Federation Aeronautique Internationale (FAI)'s "Diplome Tissandier," Stamer returned to rockets in 1939 when, with Lippisch, he also devised JATO's (see *Flugsport*, XXXI Jahrg, Band 31, 18 January 1939, p. 59). Besides this, he also eye-witnessed Eugen Sänger's ram-jet test flown on a Dornier 217 in 1941. Dr. Irene Sänger-Bredt has told the author that as a vice-director of the successor to the RRG, the Deutsche Forschungsanstalt für Segelflug (DFS) at Ainrung during the war, Stamer "tried to perform new applications of yet existing rockets in flight techniques, especially in soaring flight techniques." This unspecified work apparently translated into the JATO boosting of the huge DFS-230-A and possibly the Me 321 "Gigant" troop-carrying gliders. Stamer also contributed to the man-carrying Natter (Viper) rocket aircraft. "Thus," added Sänger-Bredt, "we never collaborated officially with Stamer on a rocket project, but my husband and Stamer became good friends. In his quality as a vice-director of DFS, Stamer procured us facilities for our experimental work as far as he could – which was very important for us in that crazy time of total war. Eugen, on the other hand, furnished consulting advice from time to time to Stamer's experiments with rocket assisted take-off, rocket braking and so on." In his later years, Fritz Stamer was a vigorous advocate of space travel, becoming a member of the Deutschen Gesellschaft für Luft- und Raumfahrt E.V. (German Society for Air and Spaceflight). On 20 December 1969, six months to the day man landed on the Moon, the world's first rocket pilot died.

Almost a year-and-a-half elapsed from the time Stamer made his flight until the next von Opel rocket plane took to the air. In the meantime, by the summer of 1928, another would-be rocket pilot appeared on the slopes of the Wasserkuppe. His name was Julius Hatry, an obscure gliding enthusiast whose performance at the Rhön-Segelflug-Wettewerbes (Rhön Gliding Competition) early in August was not outstanding. Nonetheless, this young man, who has also been described as an engineering student from Mannheim, possessed boundless enthusiasm. After witnessing or hearing of the Stamer flights he approached Lippisch with his own plans. He wished to build his own rocket glider and fly it. At first Hatry favoured Eisfeld rockets, later changed to Sander units. According to Lippisch's recollections: "I (Lippisch) helped him with the design of his glider which was built in a small carpenter's shop in a nearby village. By some chance, Fritz von Opel got wind of the project and brought pressure to bear on young Hatry to sell *him* the glider so that he could gain the publicity of making the first *official* rocket propelled flight.

The glider was then transported to a small repair shop at Frankfurt airport where it was promptly pronounced unsafe for flying without overhaul, and Hatry did not get the money that Opel had promised him." Lippisch cut off and jumps to the von Opel flight of this machine on 30 September 1929. Obviously, the plane was suitably remade and procured by von Opel. By the time it did fly it boldly bore the name "Opel-Sander Rak. 1" on its tail surfaces and in smaller letters, "Hatry Flugzeug" ("Hatry Airplane"). Typically, von Opel's vanity prevented him making it known that Hatry himself had test-flown the Rak. 1 in private before he himself took the controls for the "official" flight. Thus, Julius Hatry technically became the second man to fly in a rocket plane and von Opel the third – or fourth. But "flight" is a loosely used term here as these glider hops were barely controlled. Moreover, they too were hardly qualified successes. Harty's attempt, apparently made early in September 1929, ended in a crash landing.

What of the machine itself? The so-called Opel-Sander Rak.1 was a high-wing braced monoplane with a abbreviated nacelle of wood, aluminium, and fabric. The tail assembly consisted of dual-booms which raised the elevators and two fins clear of the rocket exhaust which emanated from the rocket units imbeded in the rear of the nacelle. The wings were parasol type, flat, with no dihedral. The cockpit was cramped enough and even more so with asbestos padding. Controls were at the left hand side of the pilot. The motor assembly comprised a bank of sixteen open steel tubes which contained Sander cartridges of 76 mm (3 in.) diameter and 457 mm (18 in.) length. Standard references say that each unit produced 50 kg (110 lb.) of thrust for 25-28 seconds for a total thrust of 900 kg (1,980 lb.) or almost a ton. However, von Opel himself provided quite different figures in a rare account published in *The Journal of the Royal Air Force College* for Spring, 1930 (Vol. X, No. 1, p. 38): "I used Sander's continuous firing (brander) rockets which gave a continuous propelling effort of 23 kilograms (50 lb.) for 25 seconds. The aeroplane was fitted with 11 continuous firing rockets and, for landing purposes, with 5 short-firing rockets." Thus, the total sustaining thrust was 550 lb. (247.5 kg). The landing rockets fitted into the five remaining tubes of the rocket bank and were meant for manoeuvring in the last few seconds [8]. All units were fired electrically from the cockpit. The empty plane weighed 180 kg (396 lb.), the loaded rockets 90 kg (198 lb.) and the allowance for the pilot was 80 kg (176 lb.) All-up weight of the plane was 770 lb. (350 kg), including boosters. Again following von Opel's description, "For propelling (boosting) purposes 3 rockets, each of 300 kilos. (6 cwt.) propelling effort, have been used. The propelling effort can be reduced in accordance with the length of the starting run. The acceleration is quite endurable for the pilot at a starting run's length of 8 metres (26 ft.) and at the required final speed of 120 kilometres (75 miles) an hour. The average speed during the flight was about 170 kilometres (106 miles) an hour." The total *boost* thrust was therefore 900 kg (1,980 lb.) thus accounting for the believed sustaining force of all the rockets. The firing time for the boost was 1.5 seconds. Few other specifications have been published. Based upon the given wing span of 39 ft. (11.8 metres), the overall length of the Opel-Sander Rak 1 is estimated at 24.5 ft. (7.5 metres) and the wing area approximately 215 ft^2 (19.9 metres^2).

Dare-devil racing driver, speedboat pilot Fritz von Opel felt the need to brush up on flying for this wholly new experience which lay ahead [9]. His instructor was the director of the Frankfurt Airport, Hellmuth Walter Wolfgang Felmy, then also a Major in the Infantry and who afterwards became a Luftwaffe General in the Second World War. This same Felmy (whom von Opel inaccurately remembered as a Captain) was to play an even greater role in the success of von Opel's flight. In the meantime, with von Opel's mechanics August Becker and Karl Treber assisting him, and perhaps Josef Schaberger too, the Sander-Rak. 1 Hatry Flugzeug and its attendant launcher were set up at the Rebstock Airport at Frankfurt for rehearsals. The unloaded airplane was first released several times from the catapult in a dry run without the rockets. Then, on 10 September 1929, von Opel himself climbed in and had the Rak 1 hooked up to "a powerful race-car," no doubt an Opel machine. As Robert Esnault-Pelterie had done 25 years earlier in testing his 1904 glider, the plane was automobile-towed and cut loose when sufficient lift was attained. Rak 1's minimum flying speed proved to be 60 mph (96.6 km/h) unaided by rockets and without benefit of the catapult. The catapult and booster rockets, von Opel assumed, would easily double this speed and more than gain enough altitude and time for sustainer ignition once cleared of the launcher. At this point von Opel set the launch date. He gave himself twenty days. The route was mapped and the press informed.

The initial scheme was a course from Frankfurt to Russelsheim, site of the Opel Automobile Works and about 10 miles (16 km) due southwest. He envisioned a huge publicity

coup, both for himself and his company. But at the last minute the Government intervened in the name of safety. There was fear that he might crash into a village or railroad station. He was thus obliged to confine the flight to the immediate environs of the Rebstock Airport, set in an otherwise uninhabited forest glade. As for the press and public, von Opel this time sincerely wished to keep them within limits, "to avoid any possible trouble with the unruly crowds." Perhaps he was alluding to past difficulties attending his other stunts. He had invited only a few papers and granted exclusive American rights to *The New York Times* and Fox Movietone for filming.

When the great day came, on 30 September 1929, it looked as if the flight was never going to be made. At 9 a.m., the air tense with excitement, von Opel shoved himself snugly into his little machine and prepared for liftoff. He waited a few moments for a favourable headwind. Just then, Major Hellmuth Felmy came up, trying to look as calm as possible despite the message he bore with the Air Police and everyone else looking on. He whispered in von Opel's ear: "A telegram just came from the Oberpraesidium in Kassel. All flight tests are forbidden. Take off quick! I haven't had the telegram yet!" [10]. "Felmy's willingness to risk his position to protect my first rocket flight from bureaucratic prohibitions," commented von Opel years later, "is something I will never forget." Yet even Major Felmy's magnaminity was not potent enough to halt all technical flaws. The order for the catapult release was given. At first, it was a grand display. Fire and smoke leapt out of the big boosters. But the sustainers failed to ignite. Gracefully, the Opel-Sander Rak. 1 Hatry Flugzeug glided back to Earth at only 50 metres (164 ft.). At 11 a.m. they were ready again. By now, impatience and lunchtime hunger pangs had gotten the better of the spectators and many of them had disappeared. Von Opel once more girded himself for liftoff. The signal was given with similar results except that this time one of the boosters also burst, the yellow hair on the back on von Opel's head being slightly singed.

Not until 3:30 or 4:00 in the afternoon was another attempt made. By now only the most fervent of aviation enthusiasts, von Opel's supporters and friends, and some of the newsmen were present. Fritz Stamer, Friedrich Sander and Frau Sellnik, von Opel's fianceé, were there. Herself a pilot and one of Germany's six aviatrixes, Frau Sellnik had been another of von Opel's professional advisors on aviation for the previous several months. After the flight (following one account) she had been the first to run up and congratulate him. Ten minutes after the flight, and still bubbling over with excitement, von Opel wrote down his impressions which he afterwards dispatched to *The New York Times* as his exclusive. "My first rocket flight!," he began. "...For today's flight I have trained for a year... For an hour before this morning's start I inspected the course and personally went over every detail of the plane – cables, fittings and rockets... Finally I draw a deep breath and then ignite. Tremendous pressure! I feel the machine racing forward. It tries to rear like a horse. Thus I race into space as in a dream, without any feeling for space or time. The machine practically flies itself. I scarcely need to touch the wheel. I only feel the boundless intoxicating joy of making a flight such as man has never made before... The force of the rockets has expired. Visions cease; actuality calls. I must return to Earth... Gliding with terrible bumps along the ground, the plane comes to a halt."

The Opel-Sander Rak. 1 came down in a cloud of black smoke badly battered, pilot intact. Partly because of his exuberance, von Opel had neglected to say how close he had come to being seriously injured and possibly killed. Exact measurements of the flight were impossible. After he had levelled off to about 100 ft. (30.5 metres) the ground crew attempted to time the flight. It was determined that he was then going at 90 mph (145 km/h). In a few moments, according to Heinz Gartmann, "a downward gust of wind, coinciding with the edge of the landing ground, caused him to make a forced landing after only using up five rockets. At a speed of 80 mph (129 km/h) this was a difficult feat, and Opel hit the ground with a crash as the landing-skid broke and the cockpit floor was shaved away, leaving him hanging by his safety-belt with an inch to spare." Officially, von Opel had been aloft for an estimated 75 seconds, attaining a maximum velocity of 95 mph (153 km/h) and had traversed a distance of nearly 5,000 ft. (1,525 metres), or 1.4 miles.

In his speech at the Deutches Museum in 1968, with the widow of Friedrich Sander in the audience, von Opel painted another picture of the events which followed the landing. "After my successful rocket flight in Frankfurt," he said, "I had to land outside the airport grounds on a potato patch, unfortunately with a tail wind and with several thrust rockets still hot. The flight speed was approximately 110 km/h (68 mph) and was too high to remain on the ground after landing, but too low to clear a raised crossroad at the end of the field. Upon impact, the landing skids, the entire cabin and a part of a wing were ripped away, but I had drawn up my legs and hung completely uninjured from the totally intact rocket frame by my safety belt. A flock of cars stampeded across the airfield with the world champion glider pilot leading the way. Stamer gathered me up, sat me on his shoulders and jumped around like a madman. While joy was reigning supreme, (mechanic Karl) Treber appeared, still shaking from what he thought had been an accident, planted himself in front of me in a rage and bellowed: "You'd think you earned a living by pulling these stunts!..."

The joy that everything had gone well did not last long. Capt. (Major) Felmy rushed up with the news that the enormous air pressure during the launch had knocked over a spectator standing 100 metres (328 ft.) away and had broken her arm. Her husband was on his way to pick up the casualty. I have to admit that I would have ten times more preferred to repeat the flight than to meet the raging husband. But before I could offer my apologies to the woman, her husband jumped out of a taxi and said to her in Frankfurt dialect the most comforting words I have ever heard: "Serves you right you stupid ass. Next time stay home with the kids."

The Imitators

Following in the footsteps of Stamer and von Opel were several imitators. In 1929 Gottlob Espenlaub flew a rocket glider which had been towed into the air by a light aircraft. This arrangement worked well on several occasions but the rocketplane finally crashed.

In 1932 there were reports of a rocket-powered bicycle with wings which the inventor launched from a German rooftop.

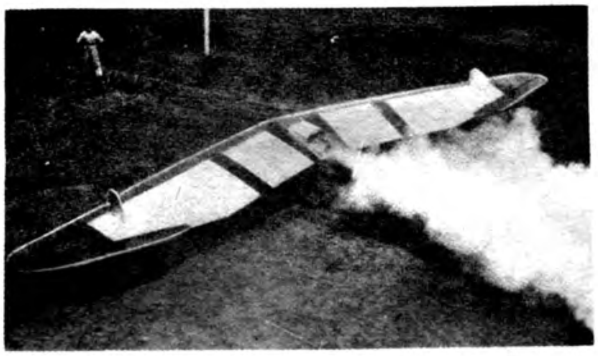
More practical work took place in America and Italy. On 1 June 1931 William G. Swan flew his 'Steel Pier Rocket Plane' over the summer resort town of Atlantic City, New Jersey, thus becoming America's first rocket pilot.

At the end of June 1931 the Italian aeronautical engineer, Dr. Ettore Cattaneo, produced his well-designed R.R.1 rocket glider which made at least four brief but successful flights at Milan's Taliedo Airport [11].

Crude as these machines were by our standards, they represented valiant if modest steps in the history of the rocket plane in this 'Century of the Shuttle.'

NOTES

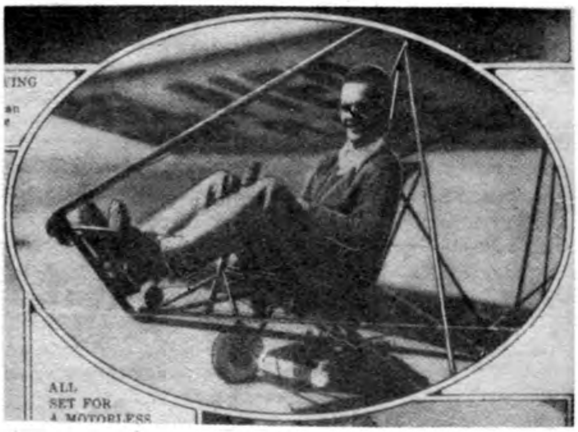
1. In a letter to the author dated 7 April 1975, Alexander Lippisch said that: "Raab and Katzenstein had some trouble



Rocket glider of the German aircraft builder Gottlob Espenlaub gets airborne at Dusseldorf in October 1930. Speed attained was 90 kmh (55.9 mph). Aircraft weighed 220 kg (485 lb) including 70 kg (154 lb) for the rockets. Total length about 2 metres (6.56 ft), wing span 12 metres (39.4 ft).

***From:** Friedrich Wilhelm Radenbach,*
*'Gottlob Espenlaub – Ein **Fliegerleben,'***
(Stuggart: K. Thienmanns Verlag, 1943).

Gottlob Espenlaub inspecting the burnt rudder after his first rocket glider flight 23 October 1929, at the Lohausen-Dusseldorf Flying Field. The plane crashed but Espenlaub escaped without injury. The rocket motors were made by Friedrich Sander who had previously made them for Fritz von Opel's rocket gliders.



William G. Swan, born 1902, American parachutist, stunt flier, rocket pioneer, at the controls of his 'Steel Pier Rocket Plane," Atlantic City, New Jersey, 5 June 1931, prior to making his second flight in the aircraft. The full thrust of the plane's 12 powder rockets was applied in the flight and the 200 lb (90.7 kg) glider rose to a height of some 200 ft (61 metres) and remained aloft eight minutes.

Times Wide World Photos
(from 'Mid-Week Pictorial', 20 June 1931, p. 5).

with von Opel. They got across (*sic*) each other, but this is a long story which I probably will tell in my memoirs." Lippisch never completed his memoirs. He died in 1976.

2. Sander published almost nothing, except a rare, generalized article in Ley's *Die Möglichkeit der Weltraumfahrt* (Leipzig, 1928).
3. According to the long-time German glider pilot Peter Riedel, Raab left the country to escape the Hitler persecutions and went to Greece; Katzenstein went to South Africa.
4. See *Aeronautics* (London) 3, 6, June 1910, pp. 33-34; and *Aeronautics* (New York), 8, 3, March 1911, pp. 81-83.
5. It has not been satisfactorily proven that the Coanda "propulseur" was really a jet. It may merely have been a large ducted air intake fan fitted around a conventional piston Clerget engine, the *exhaust gases* of the Clerget being injected rather than gasoline or other fuel as in a true jet.
6. Elsewhere in his book, Kronfield speaks highly of the promise of rockets for the future of soaring. Besides being an ideal "auxiliary motor force," he says, the rocket could also dispense with ground launching crews.
7. The *Tageblatt* story was datelined Fulda, the largest town close to the Wasserkruppe. The *Zeitung* issue of 14 June also carried an account of a Max Valier lecture entitled, "From Rocket Plane Flight to Spaceship." An overall report of Stamer's flight also appeared in the *Zeitung* for 15 June and a lengthy article by Heinrich von Sewall, "Rocket Flight and Altitude Investigation," is carried in the 17 June number. Stamer lived at Gerfeld, a village also close to the Wasserkuppe, then Germany's gliding centre.
8. Some accounts, as *The Times* (London) for 1 October 1929, state that the "braking rockets" were set in the reverse direction and meant for slowing down the plane for landings, much like retro-rockets on Apollo LEM's for landing on the Moon. However, this description does not conform to von Opel's account of the flight given above. Moreover, all available photographs of the aircraft do not show any reverse rockets, at least not on the exterior. The number of rocket holes in the rocket band, 16 in rows of four, also fits the pattern for all on-board rockets facing forward.
9. At least one reference, a biographical cartoon depicting von Opel's various feats and appearing in von Opel's *Die Geschichte der Raketenentwicklung*, indicates that he served in the (German) Air Corps during World War I and was stationed in Belgium, perhaps as a flier.
10. It is not known what time this telegram was received and its message "conveyed" to von Opel.
11. An account of the Espenlaub, Swan, Cattaneo and other rocket planes will be given by the author in a later article.

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[Continued on page 92

29TH I.A.F. CONGRESS - 3

By L. J. Carter

Continued from January issue

Technical Sessions

Communications Satellites

This ran to three sessions. The first paper, on "The Intelsat System and its future challenges" was a little light on the challenges and lacking also in answers. The second paper, on"Palapa" has already been extensively covered in *JBIS*, while the third, on "The European Communications Satellite Programme" tended to dwell rather more on the "institutional" arrangements. The system will be operational by 1981.

On the other hand, the paper on the WESTAR System broke new ground in a number of ways. It dealt with an advanced replacement to the Western Union package flying on TDRSS (Television Data Relay Satellite System) which uses a higher bit-rate than anyone else. The Satellite Switching is another new thing. This looks like being the satellite which will bring direct computer communication to roof-top plant terminals.

The final paper was a straightforward account of the Japanese CS (Sakura) and BSE (Yuri) programmes, including follow-on satellite plans.

Two paper stand out mainly from the second session. The first describes the programme of the Ariane Heavy Satellite (H-Sat). The potential of satellites for direct-to-home TV/radio is such that there now seems every chance that it will become a reality within the next decade. The ESA programme for an experimental broadcast payload is now orientated towards a mid-1982 launch with the utilisation aspect currently under discussion with the European Broadcasting Union.

There are several key operational areas e.g.

(a) Scandinavia, with a satellite broadcasting project (Nordsat) envisaged.

(b) Yugoslavia, with the aim of unifying its various cultural regions.

(c) France, Germany and Italy, already under discussion for several years. In the case of Germany it might well prove of interest to neighbouring German-speaking countries.

The second paper, which talked about new utilisation of the Symphonie system, showed just how hard the French had worked this satellite. A table listed the number of test programmes carried out and operated e.g. with China, Egypt, India, Libya, and the Soviets too. Essentially, the satellite had been given, e.g. to India, for 12 hours a day, besides providing educational TV in Africa and in Quebec for fairly short periods.

The third session took as its sub-theme "Future Systems and Technology". Seven papers were included. Several were more or less platitudinous, though a paper on "The Use of a Data Relay Satellite System for European Near-Earth Space Activities in the 80's" did indicate, at least, a study which appeared to invite further investigation.

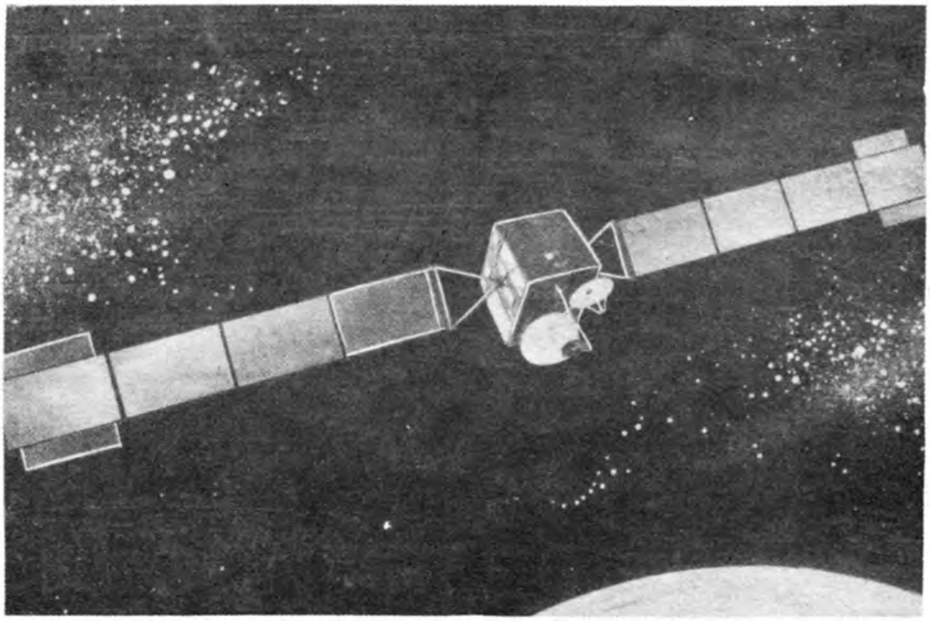
Astrodynamics

The first of three astrodynamics sessions got off to a bad start with two excellent theoretical papers marred by difficulties with projection equipment, and the third presented with such an accent that the English was very hard to follow.

"A Status Report on the First Libration-Point Satellite" was of more interest. This was more or less a progress report on ISEE-3, the first satellite which will traverse the L-1 libration point. The satellite had actually been launched from Cape Canaveral on 12 August 1978 but had not reached that point at the time of presentation of the paper.

The rather off-putting title of "Exact Analytic Formulation of Planar-Relative Motion," really described the attempt at ESOC to find an analytic solution to the very difficult problem of two bodies close together i.e. the rendezvous problem which, up to now, has only been solved by numerical means.

The second astrodynamic session was not quite so rewarding. A paper which sounded interesting i.e. "Automatic Rendezvous Scheme Proposed for an Unmanned (or Manned) Vehicle with a Space Station" was given in a heavy accent and difficult to understand. The lack of a preprint clinched



Artist's impression of H-SAT in orbit.

it. Again, the presentation of papers other than by the authors gave rise to considerable loss in effectiveness.

The most interesting note was that the paper "Design of a Tracking Filter for an Optical Target Tracker," given by a Yugoslav, which turned out to be based on his Master's Thesis taken in the UK at Cranfield, Beds!

The third session began with a highlight i.e. a paper on "Dynamics, Control and Structural Flexibility – Reports from the Hermes Mission." This was the first spacecraft to be instrumented in such a way as to determine structural characteristics while actually in orbit and transmit them to the ground. The spacecraft itself (the Canadian CTS – Communication Technology Satellite) was launched into a geosynchronous orbit in January 1976, with a deployable solar array.

The two theoretical papers which followed both used the concept of model control to determine the shape and orientation of satellites with large flexible parts, one being gravity-stabilised and the other a spinning satellite.

The paper on EXOSAT disclosed a very high level of technology. For example, there are some novel features e.g. a microprocessor, star and Moon sensors and a cold gas system with an adjustable low-pressure device so that the thrust level can be controlled, giving an accuracy in the range of seconds of arc.

This session, again, included another disappointing Soviet paper. It was supposed to describe an adaptive type of control for re-entry (it actually illustrated the Shuttle as an example) but when asked a very simple question about the atmospheric models used, the reply was made to the effect that there were apparently no numerical results or examples.

Other Technical Sessions

The above notes do not necessarily indicate the most interesting papers nor do anything other than give a small example from those presented. Manv not mentioned quite clearly contained papers of outstanding interest, particularly those on the "History of Astronautics," "Space Power Systems," "Bio Astronautics," Propulsion" (though five of the scheduled seven papers in session two of this heading failed to materialise) and the Symposium on "Space Economics and Benefits."

Business Sessions

Two Plenary Sessions were held, attended by delegates from each member-Society, in order to transact IAF business. Much of this was taken up with Reports from the IAF President, the Presidents of the International Academy of Astronautics and the International Institute of Space Law and with messages from international agencies and bodies with which the IAF enjoys reciprocal arrangements. Decisions were made to hold the 30th Congress in Munich (17-22 September 1979) and the 31st Congress in Tokyo (21-27 September 1980).

The Nominations Committee, which had met earlier and which contained representatives from Argentina, Denmark, France, Germany, Italy and Yugoslavia, reported that it

IAF Member Societies: Analysis of Financial Dues

Under $200 p.a.	42
Between $201-300	6
" $301-1000	6
" $1001-2000	1
" $3001-4000	1
Over $5000	1
Not Quoted	1
Total	58

IAF MEMBER-SOCIETIES AND THEIR MEMBERSHIPS

Asociacion Argentina de Ciencias Aeroespaciales	287
Centro de Investigationes Espaciales	40
The Astronautical Society of Australia	105
Astronautical Society of Western Australia, Limited	90
Austrian Solar and Space Agency – ASSA	
Association Belge des Ingénieurs & Techniciens de l'Aéronautique et de l'Astronautique – ABITA	110
Bulgarian Astronautical Society	100
Canadian Aeronautical & Space Institute	1419
Aeronautical & Astronautical Society of the Republic of China	814
Cyprus Astronautical Society	85
Czechoslovak Commission on Astronautics	25
Dansk Astronautisk Forening	40
Suomen Avaruustutkimusseura, Helsinki	90
Association pour l'Etude et la Recherche Astronautique et Cosmique – AERA	200
Association Aéronautique et Astronautique de France – AAAF	1250
Société Chimique de France	4000
Astronautische Gesellschaft der DDR	230
Deutsche Gesellschaft für Luft- und Raumfahrt – DGLR	3000
Hermann Oberth-Gesellschaft	1275
Hellenic Astronautical Society	75
Scientific Group for Space Research	53
Hungarian Astronautical Society	298
Indian Rocket Society	273
Indonesian Space Society	33
Iranian Astronautical Society	25
Israel Society of Aeronautics & Astronautics	100
Associazione Italiana de Aeronautica e Astronautica – AIAA	500
Associazione Italiana de Medicina Aeronautica e Spaziale	300
Consiglio Nazionale delle Ricerche	-
Instituto Italiano di Diritto Spaziale	90
Instituto Italiano di Navigazione	101
Japan Astronautical Society	100
Japanese Rocket Society	282
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Norsk Astronautisk Forening	115
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Grupo Portugése de Astronáutica	357
Rumanian National Astronautical Commission	86
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Asociatión Espñola Astronáutica	281
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Swiss Association for Space Technology – SAST	150
Swiss Transport Museum	-
Intercosmos Council – USSR Academy of Sciences	-
British Interplanetary Society – BIS	2802
Royal Aeronautical Society, Astronautics & Guided Flight Section	740
Association in Scotland to Research into Astronautics – ASTRA	27
Aerospace Medical Association	3479
American Astronautical Society – AAS	600
American Institute of Aeronautics & Astronautics – AIAA	22,000
Rocket Research Institute, Inc.	-
Yugoslav Astronautical & Rocket Society	300
Yugoslav Aerospace Society	405

had, on the nomination of the BIS, unanimously agreed to propose Roy Gibson, a Fellow of the Society and Director-General of the European Space Agency, as President of the Federation for next year. This was received with acclamation.

Vice-Presidents were agreed as L. I. Sedov (USSR), S. Saito (Japan) – both re-elected – and E. Hollax (DDR), J. Grey (USA) and R. Monti (Italy) elected for the first time.

Active participation by the Society in future IAF programmes was strengthened by the nomination of Dr. L. R. Shepherd to the IAF Programme Committee* and by his further election to the Working Group on Space Energy and Power. (Dr. Shepherd was responsible for organising a major joint "Space Power" meeting between the IAF and the IUAE in Vienna in 1972).

Social Events

Besides the Opening Reception, YARS laid on a number of half-day excursions – free – to enable participants to see some of the beautiful surrounding countryside. Unfortunately, inclement weather caused cancellation of several boat trips which were included in the list, but participants were quickly placed aboard other coaches so that no opportunity was lost to provide a most welcome relaxation.

More formal was the Medieval Dinner at the St Clara nunnery. On arrival, guests received a trumpet salute and an escort of torch-bearers, and, after the male members had donned their crimson togas (reminescent of Julius Caesar) the cocktail party began. When the guests were seated, the Rector and Council arrived to greet the guests and call them to order for the election of the "Consul for Overseas Countries." The winning candidate was presented with documents of certification, stamp of the Republic of Dubrovnik, and a dinner served in his honour!

It went off marvellously, even though there weren't enough togas to go round. The slimmers had their chance with another event, this time a concert and display of Yugoslav Folk Songs and Dances. By all accounts, it was very enjoyable and was only marred by the return of everyone to the hotel earlier than expected, with the consequent earlier-than-anticipated disruption of what had promised to be a peaceful evening.

* *Papers for Presentation to IAF Congresses are solicited by an International Programme Committee which is appointed by the Federation itself.*

As is customary and now an old – established practice, the Congress ended with a Banquet at Libertas on Friday, 6 October, during which several awards were made and which continued on into the small hours with music and dancing. Congresses actually end in rather funny ways. This one was no exception. While closeted in friendly fashion outside the "Taverna" in the bowels of Libertas, a loud stentorian voice echoed down and down from the balconies above. "Len Carter" – it said "Go to Bed!"

There was nothing for it . One does not challenge the Almighty, especially when there is a long and tedious air journey laid on for the following day.

The IAF Congresses

The I.A.F. holds a congress each year, attended by 500 to 1,000 participants, most of whom are specialists in particular fields

Apart from the main theme selected for presentation and discussion at the opening session, the scientific and technological subjects appearing most frequently in the programme are:

(a) fluid mechanics in space applications;
(b) propulsion;
(c) energy problems for space vehicles;
(d) materials and structures;
(e) astrionics;
(f) bioastronautics;
(g) space transportation;
(h) reliability of space systems;
(i) application satellites: meteorology, communications, Earth resources, geodesy and geodynamics, manned stations, and space laboratories;
(k) solar system exploration;
(l) supervised youth rocket experiments;
(m) education in astronauts.

In addition the I.A.F. organizes conferences for students, with prizes awarded for the best papers.

During the Congress, the International Academy of Astronautics holds international symposia on subjects such as:

(a) space economics and benefits;
(b) rescue and safety in space operations;
(c) communication with extra-terrestrial intelligence;
(d) space relativity;
(e) history of astronautics.

The International Institute of Space Law holds a colloquium during the Congress to discuss international implications of legal problems resulting from space activities.

George James *(Fellow)* and Jim Harford *(Fellow* and Executive Secretary of the AIAA) exchange greetings outside Hotel Libertas.

Philatelic Contribution. The Yugoslav Post Office issued a special stamp on the occasion of the Congress. All letters and cards mailed in Dubrovnik during the Congress were also marked with a special cancellation. Unfortunately the stamp, though attractive, is rather dark in tone and doesn't lend itself to reproduction as an illustration.

APPENDIX

THE INTERNATIONAL ASTRONAUTICAL FEDERATION:– What it is, What it does

Introduction

The International Astronautical Federation (I.A.F.) is a non-governmental association of national societies, founded in 1950 with 11 members, now composed of 58 members from 36 countries.

The aims of the IAF are to encourage the development of astronautics for peaceful purposes and to ensure widespread dissemination of scientific and technical information on space matters.

A major function of the IAF is to encourage astronautical research, which it does by bringing together scientists and engineers from different disciplines during its annual Congresses and various specialised meetings.

The Federation cooperates with many other international organisations interested in different aspects of astronautics or involved in the peaceful use of outer space.

In 1960, the Federation created the International Academy of Astronautics (I.A.A.) and the International Institute of Space Law (I.I.S.L.) both of which operate autonomously but co-operate closely with the Federation.

Aims and Objectives

Within a framework of international co-operation the Federation examines problems related to space technology, space science as well as all the applications which space can introduce to improve man's condition on Earth.

These aims are accomplished with support from member societies to promote the purposes set out in the I.A.F. Constitution, viz:–

(a) Foster the development of astronautics for peaceful purposes.
(b) Encourage the widespread dissemination of technical and other information concerning astronautics.
(c) Stimulate public interest in and support for the development of all aspects of astronautics through the various media of mass communication.
(d) Encourage participation in astronautical research or other relevant projects by international and national research institutions, universities, commercial firms and individual experts.
(e) Create and foster as activities of the Federation academies, institutes and commissions dedicated to continuing research in, and the fostering of, all aspects of the natural and social sciences relating to astronautics and the peaceful use of outer space.
(f) Convene and organize, with support of its respective academies, institutes and commissions, international astronautical congresses, symposia, colloquia and other scientific meetings.
(g) Co-operate and advise with appropriate international and national, governmental and non-governmental organizations and institutions on all aspects of the natural, engineering and social sciences related to astronautics and the peaceful uses of outer space.

How it Began

In September 1950, the first International Astronautical Congress was held in Paris, on the initiative of the astronautical societies in the Federal Republic of Germany, France, and the United Kingdom. Delegates from these societies, joined by delegates from societies in Argentina, Austria, Denmark, Spain and Sweden, met with the intention to form an international association or federation "to promote the development of interplanetary travel".

During this first Congress, a provisional committee, under the chairmanship of Dr. Eugen Sänger (FRG), was formed to lay the foundations of the Federation.

In September 1951 in the following year, in London, a second Congress was held with the same participants and, in addition, with delegates of astronautical societies in Italy, Switzerland and the U.S.A.

The first Constitution of the International Astronautical Federation was formally adopted in 1953, at Stuttgart (FRG). It was subsequently modified and amended several times, the last amendments having been introduced in 1974.

Committees have been set up over the years to study specific problems. There is, for example, the Bio-astronautics Committee, the Education Committee, and the Committee on Applications Satellites. The committees contribute to the IAF Congress programme in support of the International Programme Committee.

The evolution of the Congress programmes emerges when one looks at the subjects studied since the first Congress in 1950, which was limited to reports on activities in the different countries forming the Federation at that time. In 1951 (London), a technical programme was set up with three subjects: satellites, rockets for satellites, and space stations. Gradually, new topics appeared. In Washington in 1961, for example, the programme dealt with space propulsion, astrodynamics, energy conversion, research on combustion, bioastronautics, solar system exploration, space vehicles, structures, instrumentation. Starting with the Congress in Baku in 1973, in addition to the various topics regularly discussed, it was decided to choose a particular theme for each Congress, viz.:

1973: Space Activity – Impact on Science and Technology
1974: Space Stations, Present and Future
1975: Space and Energy
1976: A New Era of Space Transportation
1977: Using Space – Today and Tomorrow
1978: Astronautics for Peace and Human Progress

These themes are developed during a special invited lecture at the opening session and are emphasized in other sections of the programme.

Membership and Organisation

The Federation has three categories of members:

(1) **National Members**
Several astronautical societies from the same country can be admitted as national members but only one national member in each country can vote on matters discussed by the General Assembly.

(2) **Institution Members**
Universities, schools, institutes, or laboratories involved in education or research in the field of astronautics can be admitted as institution members.

COME AND JOIN US

The Yugoslav Astronautical and Rocket Society (YARS) as the Host Society of the XXIXth Congress of the International Astronautical Federation (IAF) is honored to have the opportunity to invite you to attend this exceptional convention.

The Congress will be held under the high patronage of the President of the Socialist Federative Republic of Yugoslavia, Josip Broz Tito.

Come and join hundreds of leading specialists involved in space research and peaceful uses of its results for the benefit of all mankind.

Dubrovnik, known throughout the world as a pearl of the Adriatic Coast is ready to offer its traditional hospitality to all participants of the IAF 78 Congress. The historic city, a thousand year treasury of cultural and historical monuments, will extend ideal conditions for the undisturbed and fruitful work and pleasant rest of the delegates and other participants in the Congress.

The Yugoslav Organizing Committee of the XXIXth Congress, and other institutions cooperating in the preparation of this important international scientific meeting, extend a warm welcome to all those who contemplate attending the Congress in Dubrovnik.

Welcome – Dobro došli!

This is a typical invitation extended annually by the Host member society of the IAF Congress. Next year the Congress will be held in Munich, Germany, from 17-22 September 1979. With the DGLR as Host Society.
Won't you join us there?

(3) **Associate Members**
International organizations whose purposes and activities are in accordance with the objectives of the I.A.F. can be admitted as associated members.

The Bureau

The Bureau consists of a President and five Vice-Presidents elected each year by the General Assembly, and the last-retired President. The Presidents of the I.A.A. and I.I.S.L., and the General Counsel are also members of the Bureau but do not vote. The President is the chief executive officer. He represents the Federation at public ceremonies and events in which the Federation participates, presides at the plenary meetings of the General Assembly and at all meetings of the Bureau, and reports the conclusions and recommendations of the Bureau to the General Assembly.

The role of the Bureau is as follows:
(a) to receive and examine applications for membership;
(b) to invite potential members to the plenary meetings of the General Assembly as observers;
(c) to invite to the plenary meetings observers of organizations that are not members but are interested in the development of astronautics;
(d) to recommend the expulsion of members that fail to meet their obligations;
(e) to recommend and supervise the organization of colloquia, symposia, meetings, and congresses of the Federation;
(f) to prepare and submit the agenda for meetings of the General Assembly;
(g) to recommend to the General Assembly actions relating to the annual contributions of members;
(h) to accept grants and donations for the Federation;
(i) to designate interim committees for specific tasks.

PRESIDENTS OF THE IAF

The Presidency of the IAF, which is limited to a term of two successive years, has always been filled by eminent men, internationally known for their aerospace activities, as follows:

E. Sänger (FRG)	1951-1953
F.C. Durant III (USA)	1953-1956
L.R. Shepherd (UK)	1956-1957
A.G. Haley (USA)	1957-1959
L.I. Sedov (USSR)	1959-1961
J. Perez (France)	1961-1962
E.A. Brun (France)	1962-1964
W.H. Pickering (USA)	1964-1966
L.G. Napolitano (Italy)	1966-1968
E. Carafoli (Rumania)	1968-1970
A. Jaumotte (Belgium)	1970-1972
L.G. Napolitano (Italy)	1972-1974
L. Jaffe (USA)	1974-1976
M. Barrere (France)	1976-1978
R. Gibson (UK)	1978-

The President is elected annually by the IAF Member-Societies at a Plenary Session, on the recommendation of the Nominations Committee.

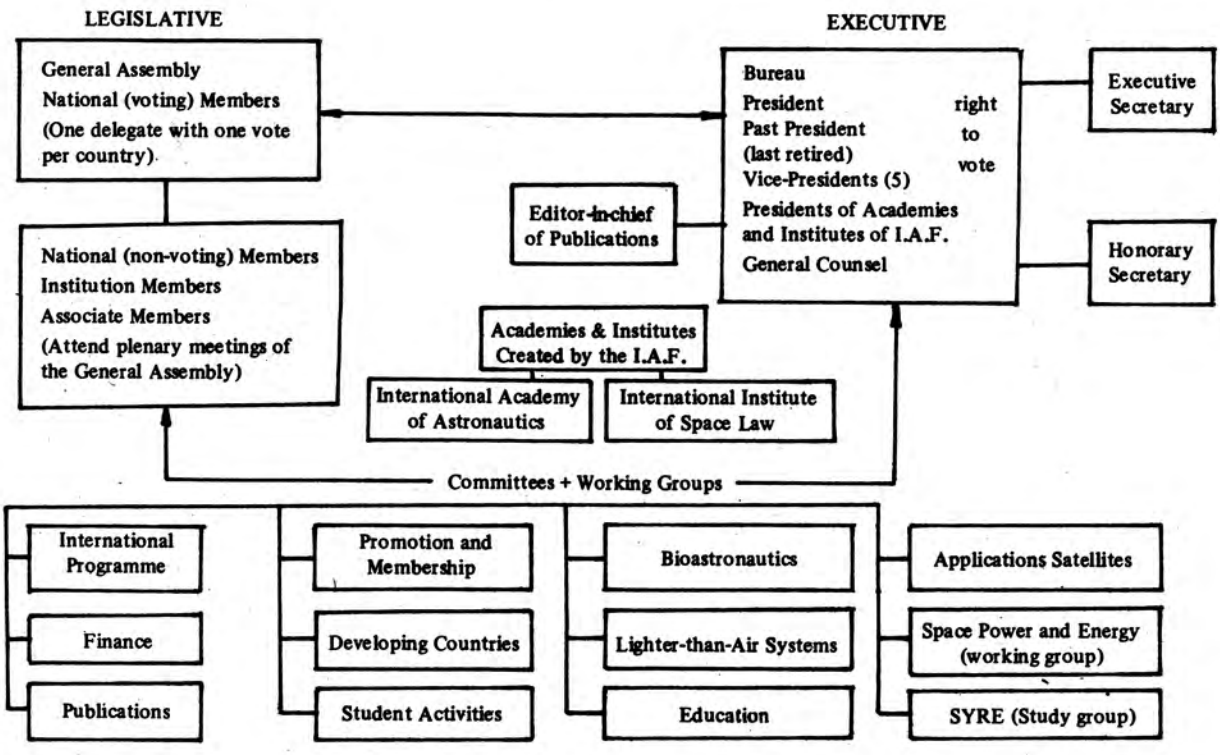

Fig. 1 shows that the Federation functions at three levels. First are the committees set up by the General Assembly, which prepare proposals within the framework of their mandates and submit recommendations to the President for consideration by the Bureau.
Next is the Bureau where questions of interest to the Federation are discussed and sorted out in order to provide the facts and arguments necessary for the President to present them to the General Assembly.
Third is the General Assembly, which votes on the recommendations of the Bureau and decides on all actions to be taken. This is the most important level since all decisions rest with the General Assembly.

29th IAF Congress logo.

Committees

Members of committees are appointed by the General Assembly upon the recommendation of the Bureau. They are appointed for a two-year term, and may be re-appointed without limitation. These members are chosen for their individual ability. The tasks of the Committees are varied: for some, they consist in strengthening the Federation's organization or improving its operation and prestige; for others, they involve studies in various fields of science and technology, especially through the establishment of specialized working groups. Committees can be dissolved if they are no longer active, or replaced or reorganized according to the needs of the Federation.

The principal committees of the Federation are as follows:

(1) **International Programme Committee:** Its role is:

(a) propose the theme of the Congress;
(b) propose subjects for the scientific and technical sessions;
(c) propose session chairmen;
(d) select the papers to be presented;
(e) assure the proper organization and conduct of the sessions.

(2) **Publications Committee:** Concerned particularly with the form of I.A.F. publications and procedures.

(3) **Finance Committee:** examines and studies the annual budget of the Federation and makes recommendations for improving the financial situation and obtaining adequate resources. (The Committee is chaired by a member of the Bureau).

(4) **Committee for the Promotion of Activities and Membership:** A most important objective of this Committee is to improve and up-date the Federation's activities and think about its future. It also seeks ways to expand the membership in order to establish contact with a maximum number of organizations that are interested in activities within the scope of the Federation. (The Committee is chaired by a member of the Bureau).

(5) **Education Committee:** The role of this Committee is not only to compare educational programmes relating to astronautical disciplines but also to see how the utilization of space techniques can cause a revolution in teaching methods, both by the transmission of courses by the best teachers in a certain discipline, and by mass education in the developing countries. International co-operation in this field is desirable and far-reaching.

(6) **Bioastronautics Committee:** The purpose of this Committee is to discuss and promote all activities relating to this discipline, especially man's role in them. International co-operation in this field is important.

(7) **Committee on Space Applications:** The field covered by this activity is vast and directly connected with living conditions on the Earth: Earth resources, meteorology, ecology, telecommunications.

(8) **Committee on Lighter-than-Air System (LAS):** Balloons offer many possibilities for civilian uses, such as transportation of heavy loads and operating low altitude TV stations; this Committee is trying to find additional ways to use balloons.

(9) **Committee on Developing Countries:** The objective is to find out what astronautics can give to the developing countries not only to improve their standard of living but also to improve their systems of education and information. (The Committee is chaired by a member of the Bureau).

(10) **Student Activities Committee:** The main purpose of this Committee is to centralise student activities in the Federation: the organization of student conferences, the establishment of contacts between students of different countries, and assistance with other youth projects that may be introduced.

(11) **SYRE Study Group:** The purpose of this study group on "Supervised Youth Rocket Experiments" is to assemble information on youth activities concerned with experimental model rocketry, e.g. rocket construction and scientific payloads, and to provide guidelines for maximum safety in these activities. The Study Group has produced a document that will serve as a safety manual for experimental programmes in this area.

(12) **Space Power and Energy Working Group:** The purpose of the Working Group is to call attention to new space concepts and developments to meet energy needs on Earth from an international standpoint, and to ways of co-ordinating international and national activities in this area.

Officers

The Federation has an Honorary Secretary residing in Switzerland where the Federation is domiciled, and an Executive Secretary, both appointed by the Bureau. The Executive Secretary is responsible for the operation of the Secretariat, which provides the administrative support at three levels: the Bureau, the General Assembly, and Committees.

The General Assembly

This is composed of delegates of national voting-members, The General Assembly has the following powers and functions:

(a) examine and approve the credentials submitted by delegates;
(b) approve and modify the agenda of its meetings submitted by the Bureau;
(c) elect new members;
(d) suspend the rights of defaulting members;
(e) approve financial reports proposed by the Bureau;
(f) appoint committee members;
(g) elect Bureau members;
(h) create academies, institutes, and commissions necessary to pursue the Federation's work, and approve their statutes;
(i) approve amendments to the Constitution.

Delegates of all other classes of member may attend plenary meetings of the General Assembly and participate in its discussions.

Official Languages

The official languages are English, French, German, Spanish and Russian. As working in several language has become impossible

IAF Member Societies: Analysis of Membership Totals

Totals	*No. of bodies*
Up to 100 Members	18
Between 101-200 Members	9
" 201-300 Members	8
" 301-400 Members	2
" 401-500 Members	1
" 501-1000 Members	6
" 1001-2000 Members	3
" 2001-3000 Members [1]	2
" 3001-4000 Members [2]	2
Over 20,000 [3]	1
Not quoted	6
Total	58

[1] BIS, DGLR; [2] Aerospace Medical Association and Societe Chemique de France; [3] A.I.A.A.

both materially and financially, English is being used more and more, particularly at meetings, because it is the language most accessible to scientists and engineers in all countries.

Budget

The main part of the Federation's budget, about 40-50%, is derived from membership dues.

Next comes a share of the registration fees paid by participants in the congresses. The amount depends on the attendance, which varies from year to year between 500 to 1,000 persons. It is thus an unpredictable item of income that can provide anywhere from 30-50% of the budget.

The third source of income, about 10%, arises from revenue from publications and bank interest.

The life of the Federation depends to a large degree on the number of its members and on the success of the annual congresses. It is therefore imperative for the Federation to increase its membership and to prepare congresses that will attract a large audience.

Associated Organisations

International Academy of Astronautics (IAA)

The International Academy of Astronautics electes members in three Sections, i.e. Basic Sciences, Engineering Sciences and Life Sciences. At present the Academy has 534 Members and Corresponding Members and 11 Honorary Members, coming from 31 countries.

The Academy organizes international symposia and colloquia both within the framework of the annual IAF Congress and at other times and elsewhere. Besides the proceedings of these scientific meetings, the Academy publishes the journal, Acta Astronautica, and has published an Astronautical Multilingual Dictionary in seven languages.

Information on current Academy's activities is regularly up-dated in annual report of the President made to the IAF Assembly.

Controls rested in a Board of Trustees, consisting of the following:–

President:	C.S. Draper (USA)
Past-President:	F.J. Malina (USA)
Vice-Presidents:	H.A. Bjurstedt (Sweden)
	E.A. Brun (France)
	A. Mikhailov (USSR)
	L.G. Napolitano (Italy)

Trustees:–

Section 1
M. Nicolet (Belgium), Chairman
N. Boneff (Bulgaria)
A. Dollfus (France)
F.L. Whipple (USA)

Section 2
R. Pesek (Czechoslovakia), Chairman
A. Jaumotte (Belgium)
J.M.J. Kooy (The Netherlands)
L.I. Sedov (USSR)

Section 3
R. K. Andjus (Yugoslavia), Chairman
O.G. Gazenko (USSR)
A. Graybiel (USA)
E.A. Lauschner (FRG)

Legal Counsel:
V. Kopal (Czechoslovakia)
Secretary:
H. van Gelder (USA)

The International Institute of Space Law (IISL)

The International Institute of Space Law has individuals elected from 48 countries. The Institute organizes an annual Colloquium on the Law of Outer Space, which takes place during the IAF congresses and deals with different legal aspects of the peaceful uses of outer space. Since 1958 nineteen colloquia of this kind have been held, the proceedings of which have been regularly published.

The Institute has also conducted a survey of the teaching of space law throughout the world and organized symposia on this subject. It published an annual Worldwide Bibliography of Space Law and Related Matters for the years 1964 to 1973.

Control is vested in a Board of Directors, the membership of which is as follows:–

Hon. President:	E. Pepin (France)
President:	I.H. Ph. Diederiks-Verschoor (The Netherlands)
Vice-Presidents:	E. Galloway (USA), G.P. Zhukov (USSR)
Secretary:	E. Fasan (Austria)

Members of the Board:–

M.G. Bourely (France)	N.M. Matte (Canada)
A.A. Cocca (Argentina)	A. Priyatna (Indonesia)
S.R. Estrade (Spain)	G. Reintanz (GDR)
M. Herczeg (Hungary)	H. Safavi (Iran)
V. Kopal (Czechoslovakia)	M. Smirnoff (Yugoslavia)
P. Magno (Italy)	E. Wyzner (Poland)

Relations with International Organizations

As important aspect of the Federation's activity is to establish a close relationship with various international governmental and non-governmental organizations concerned with astronautics or related fields.

Among the governmental organizations are relations with the United Nations (UN), particularly with the Committee on the Peaceful Uses of Outer Space and its Sub-Committees. Numerous I.A.F. observers participate in their meetings and have contributed, for example, to the evaluation of Earth resources observed by satellites and the utilization of other data and systems, especially in developing countries.

The Federation also has relations with UNESCO, the World Health Organization (WHO), the World Meteorological Organization (WMO), the International Telecommunication Union (ITU), and the International Atomic Energy Agency (IAEA).

Among the non-governmental organizations, there is IFAC (International Federation of Automatic Control) which organizes congresses in which the I.A.F. co-operates.

There is still a need for co-ordination and agreement especially with COSPAR, the "Committee on Space Research" of the International Council of Scientific Unions (ICSU). In some areas, the activities of the I.A.F. and COSPAR are so closely related as to create a risk of duplication and consequently a certain amount of conflict in their programmes.

The IAF has an increasingly important role to play in every field of space activity, particularly when programmes need co-ordination at an international level. From that point of view, the Federation occupies an unique place in the international scene.

I.A.F. STUDENT AWARDS

Presentation of I.A.F. Student Awards during the Dubrovnik Congress were as follows:

Graduate Students:
1st prize (with Marial medal): R. Courtin, (France); 2nd prize, shared equally between A. H. Bellenkes, (USA) and D. Laroche, (France); 3rd prize D. J. Richer (UK).

Undergraduate Students:
1st prize (with HOG medal): S. Kent, (USA); 2nd prize, shared equally between T. Duhamel, (France) and R. W. Ridenoure, (USA); 3rd prize, shared equally between B. Zupanic, (Yugoslavia) and V. Poulec, (Czechoslovakia).

16TH EUROPEAN SPACE SYMPOSIUM

During 1979 the Council will be actively promoting a number of steps to expand the Society's activities in the international scene. Among the most important of these will be the extension of the European Space Symposium into a three-day event.

The meeting, which will be held in Stresa, in Northern Italy, from Tuesday 3 July to Thursday 5 July 1979, will take as its theme "Current and Potential European Space Projects."

Registration Forms and other details will be available to those interested nearer the date. Please apply to the Executive Secretary as soon as possible with offers of papers for presentation and/or requests for further information.

SATELLITE DIGEST - 123

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed summary of the information presented can be found in the January, 1979 issue.

Continued from January issue, p. 43]

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclination (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Cosmos 1033 1978-89A 11039	1978 Oct 3.46 12.84 days (R) 1978 Oct 16.30	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	204 213	234 239	81.40 81.38	88.94 89.08	Plesetsk A-2 USSR/USSR (1)
Progress 4 1978-90A 11040	1978 Oct 3.965 22.74 days 1978 Oct 26.70	Sphere + cone-cylinder + antennae 7000?	8.0 long 2.3 dia	185 272 325 187	248 318 347 356	51.65 51.65 51.64 51.64	88.76 90.36 91.19 89.88	Tyuratam A-2 USSR/USSR (2)
Cosmos 1034 1978-91A 11042	1978 Oct 4.15 8000 years	Spheroid 40?	1.0 long? 0.8 dia?	1422	1483	74.04	114.97	Plesetsk C-1 USSR/USSR (3)
Cosmos 1035 1978-91B 11044	1978 Oct 4.15 7000 years	Spheroid 40?	1.0 long? 0.8 dia?	1402	1482	74.01	114.74	Plesetsk C-1 USSR/USSR (3)
Cosmos 1036 1978-91C 11045	1978 Oct 4.15 9000 years	Spheroid 40?	1.0 long? 0.8 dia?	1441	1483	74.04	115.19	Plesetsk C-1 USSR/USSR (3)
Cosmos 1037 1978-91D 11046	1978 Oct 4.15 9000 years	Spheroid 40?	1.0 long? 0.8 dia?	1461	1484	74.02	115.41	Plesetsk C-1 USSR/USSR (3)
Cosmos 1038 1978-91E 11047	1978 Oct 4.15 10000 years	Spheroid 40?	1.0 long? 0.8 dia?	1476	1489	74.05	115.64	Plesetsk C-1 USSR/USSR (3)
Cosmos 1039 1978-91F 11048	1978 Oct 4.15 10000years	Spheroid 40?	1.0 long? 0.8 dia?	1480	1552	74.04	116.38	Plesetsk C-1 USSR/USSR (3)
Cosmos 1040 1978-91G 11049	1978 Oct 4.15 10000 years	Spheroid 40?	1.0 long? 0.8 dia?	1480	1527	74.03	116.11	Plesetsk C-1 USSR/USSR (3)
Cosmos 1041 1978-91H 11050	1978 Oct 4.15 10000 years	Spheroid 40?	1.0 long? 0.8 dia?	1478	1509	74.03	115.88	Plesetsk C-1 USSR/USSR (3)
Cosmos 1042 1978-92A 11052	1978 Oct 6.64 12.57 days (R) 1978 Oct 19.21	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	180 174 166	306 325 329	62.80 62.80 62.81	89.37 89.49 89.46	Plesetsk A-2 USSR/USSR (4)
GPS 3 1978-93A 11054	1978 Oct 7.1 indefinite	Cylinder + 4 vanes 450?		20283	20310	62.81	722.60	ETR Atlas F DoD/USAF (5)
Cosmos 1043 1978-94A 11055	1978 Oct 10.82 60 years	Cylinder + 2 vanes? 2500?	5 long? 1.5 dia?	620	634	81.20	97.31	Plesetsk A-1 USSR/USSR
Molniya 3 (10) 1978-95A 11057	1978 Oct 13.21 12 years?	Cylinder-cone + 6 panels + 2 antennae 1500?	4.2 long? 1.6 dia?	432 423	40828 39925	62.79 62.82	736.20 717.65	Plesetsk A-2-e USSR/USSR (6)
Tiros 11 1978-96A 11060	1978 Oct 13.474 1000 years	Cylinder 734	3.71 long 1.88 dia	849	864	98.92	102.13	WTR Atlas F NOAA/NASA (7)
Cosmos 1044 1978-97A 11065	1978 Oct 17.63 12.65 days (R) 1978 Oct 30.28	Sphere + Cylinder-cone? 5500?	5 long? 2.4 dia?	205	292	62.82	89.48	Plesetsk A-2 USSR/USSR
Nimbus 7 1978-98A 11080	1978 Oct 24.343 1200 years	Truncated cone + 2 panels 907	3 long 1.5 dia	943	955	99.28	104.09	WTR Delta NASA/NASA (8)

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Intercosmos 18 1978-99A 11082	1978 Oct 24 15 years	Octagonal ellipsoid? 550?	1.8 long? 1.5 dia?	414	761	82.97	96.49	Plesetsk C-1 USSR/USSR (9)

Supplementary notes:

(1) A redundant manoeuvring engine, designated 1978-89C separated during 1978 Oct 14. Orbital data are at 1978 Oct 3.6, and Oct 3.9.

(2) Unmanned supply vehicle carrying fuel and other consumables for the Soyuz 29 crew aboard Salyut 6. Docking took place 1978 Oct 6.042 (0100 UT). Refuelling was completed by Oct 13 and on Oct 20, the Progress 4 engines were used to raise the Soyuz 31-Salyut 6-Progress 4 complex from a 321 x 340 km orbit to a 359 x 362 km one. Progress 4 separated from Salyut during 1978 Oct 24; orbital data are at 1978 Oct 4.4, Oct 7.5 and Oct 26.2

(3) Multiple launch of eight satellites which are probably used for military communications.

(4) A redundant manoeuvring engine, designated 1978-92C, separated during 1978 Oct 18. Orbital data are at 1978 Oct 6.9, Oct 14.1 and Oct 17.0.

(5) Third satellite in the US Global Positioning System, based on the NAVSTAR system. The two previous launches are 1978-20A and 1978-47A.

(6) Soviet domestic communications satellite carrying telephone, telegraph, radio and TV. This satellite is probably a replacement for 1976-127A, Molniya 3 (6).

(7) Operational US weather satellite providing real-time meteorological information. Onboard instruments scan the Earth in various regions of the spectrum and the satellite transmits the data to the ground as pictures and instrument readings. The satellite is designed to operate for two years.

(8) US environmental satellite designed to study the atmosphere's physical characteristics and search for evidence of both natural and man-made pollutants.

(9) International co-operative satellite for studies of the magnetosphere and ionosphere. Countries taking part include the USSR, Czechoslovakia, the GDR, Hungary, Poland and Roumania.

Amendments:

1965-09A, Pegasus 1 decayed 1978 Sep 17.26, lifetime 4960.65 days.
1970-17A, DIAL/WIKA decayed 1978 Oct 5, lifetime 3131 days.
1971-83B, TTS 3 decayed 1978 Sep 19, lifetime 2547 days.
1978-29A, a Big Bird satellite decayed 1978 Sep 11, lifetime 178 days.
1978-39A, BSE 1 is irregular in shape, 3.09 x 1.32 x 1.2 m in size. It has two solar panels.
1978-64A, Seasat 1, add a further orbit of 792 x 794 km, 100.76 min. 108.02 deg after manoeuvres. Orbital data are at 1978 Jun 27.1 and 1978 Sep 22.9. Seasat ceased to function on 1978 Oct 10 after a short circuit; engineers hope to revive it when the orbit has moved to such a position that the spacecraft is in continuous sunlight.
1978-79A, ISEE 3 is cylindrical and 1.61 m long, 1.73 m diameter.
1978-81A, Soyuz 31 was recovered with the Soyuz 29 crew 1978 Nov 2.462 (1105 UT), lifetime 67.843 days. The Soyuz 29 crew was in flight for 139.616 days (139 days 14 hours 48 minutes).

1928-1929 FORERUNNERS OF THE SHUTTLE: 'THE VON OPEL FLIGHTS'/ *Continued from page 83]*

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BOOK REVIEWS

Planetary Nebulae
Ed. Yervant Terzian. D. Reidel Publishing Company, 1978, pp. 376, $37.00 (Paperback $24.00).

This book presents the proceedings of the International Astronomical Union Symposium No. 76 held at Cornell University in June 1977. It contains the text of invited papers and abstracts of contributed papers.

In general appearance this book seems well set out in logical order, split into sections dealing with the eight sessions on Distribution, Observations, Physical Processes, Central Stars, Chemical Abundances, Evolution and Morphology, and Origin of Planetary Nebulae (PN), plus a session on their influence on the rest of the Galaxy. Photographs and diagrams are adequate and certainly clear enough for their purpose.

Why are PN studied? Apart from their esoteric appearance it is probable that most stars of intermediate mass, i.e. 1-4 solar masses, that being a reasonable percentage of the Galaxy, produce a PN during their lifetime. A PN, therefore, could be a standard phase between a red giant and a white dwarf so it is evident that their study is important to understand the concept of stellar and galactic evolution.

Of particular interest were the papers on chemical abundances. It appears that a secure knowledge on chemical abundances of PN is crucial to their study, enabling speculation to be made on the origin and evolution of the progenitor stars and adding light to the chemical abundances in the interstellar medium. The study of elements, difficult to observe in stars, is often easier in PN. Optical observations have been supplemented in recent years by ultra-violet, infra-red, and radio studies, the UV observations being made from sounding rockets and satellites.

Although now in other fields, Ian W. Roxburgh of Queen Mary College presents an interesting and straightforward paper on the evolution of PN, considering methods by which material is ejected from the stars.

A review book such as this provides a very convenient source of information and a starting point for research. It should be bought as a matter of course by any group researching into PN. No doubt it will end up in many university libraries, but its cost is prohibitive for an individual.

Finally, a humorous quotation from the book by S. P. Wyatt, University of Illinois: "Perhaps we should have said, for the number of planetary nebulae in the Galaxy, 20,000 or 30,000 plus or minus 25,000!"

R. S. MACDONALD

Pioneer Odyssey
By Fimmel, R. O., Swindell, W. and Burgess, E., NASA SP-349 , obtainable from U.S. Government Printing Office, Washington, 1977, pp. 219, $9.85.

This is the revised edition of an earlier publication dealing with the Pioneer 10 mission to the outer Solar System, expanded to include the results obtained by Pioneer 11.

The book is attractively presented in hard covers and large format. While really being a history of the whole Pioneer F and G project from its inception in June 1969, scientific results are presented in an accurate, easily readable style. An introductory chapter summarises in broad outline our present knowledge of the planets.

Solar System researchers will find particularly useful the technical details of the Pioneer 10 and 11 images presented in Appendix 2 and the large number of examples (many in colour) given in the text. Particularly valuable are the original blue and red images from the Spacecraft which appear opposite full page colour photographs of Jupiter.

The book is beautifully produced, easy to read, and forms a useful contribution to the literature. It is probably the most up to date text on Jupiter currently available. Full details of the engineering aspects of the mission, spacecraft design, launch and function, trajectory refinement, micrometeoroid results and results of investigations of the Zodiacal Light, Gegenschein and Asteroid Belt are accurately presented and data on the Jovian magnetosphere makes fascinating reading. The best images of the four large satellites of Jupiter to date are also given and the retargetting of Pioneer 11 to Saturn is covered adequately, although the decision to fly outside the ring system probably came after the book went to press. It is mentioned in the text as an option.

Unfortunately, parts have suffered from lack of proofreading. Fig. 9-11a (the Pioneer 11 close up of the Great Red Spot) and 9-14a have been inadvertently transposed and there are some small factual errors in the text, and one discrepancy. Fig. 5-16 is viewed from the north ecliptic pole and not the north celestial pole as stated; likewise Fig. 5-18 is viewed from the north celestial pole of Jupiter. The 14th satellite of Jupiter referred to on page 83 has not yet been officially confirmed. Unfortunately the names used for the outer moons of Jupiter throughout the text are not those accepted by the IAU: satellite IX is named Sinope. The book uses "Hades" throughout: a name which was in use unofficially some years ago. Fig. 6-4 gives the mass of Callisto as 1.47 lunar masses, yet the text on the same page (p. 101) gives a value of 1.44 lunar masses. As there is no further reference to the matter it is impossible to know which value is correct.

The chapters of the book are interspersed with examples of artwork which seem to serve no useful function and can even be misleading. The painting on p. 138 shows the belts of Jupiter in the wrong position in relation to the terminator, indicating an axial tilt of about 30° for the planet. Whereas the correct value is 3°).

ROBERT A. MACKENZIE

Multiple Periodic Variable Systems
By Walter S. Fitch, D. Reidel Publishing Company, 1976, pp. 348

This book contains the fifteen invited papers and the discussions which followed them given at I.A.U. Colloquium 29 in Budapest in September 1975. The papers cover a variety of topics under the general title of muliple periodic variable stars from both theoretical and the observational points of view. The following classes of objects are discussed in one or more of the papers: β Cephied stars, Ap Stars, β Canis Majoris stars, Miras, Cephieds, RR Lyrae stars, δ Scuti stars, cataclysmic variable and white dwarfs, and RS CVn binaries. Although all of the papers gave useful reviews, the three discussed below were of great interest.

R. S. Stobie in his review of Cephieds concentrated on the observations and particularly those of the double-mode Cephieds. These stars have two periodic oscillations which beat to give the observed light curve. If it is assumed that these periods are the fundamental and the first overtone then it is possible to derive both the mass and the radius of

the star without knowing the distance. This paper was followed by a theoretical discussion of Cephied pulsations by Cox and Cox.

D. S. Hall in his paper about the RS CVn binary stars starts by proposing a new definition of the class. These stars consist of binary stars with periods in the range 1 to 11 days where the hotter star is of spectral type F or G and the cooler of G or K. He then gives a collation of data on these systems including such things as radio observations, masses, etc. He finally discusses the possible relation between RS CVn binaries and other short period binary systems. This paper is a very useful collection of data on these stars and it will be interesting to see how the data in it changes in the next few years.

Warner discusses dwarf novae systems and the SU UMa subgroup in particular. These binary systems consist of a white dwarf and a red dwarf with the latter losing mass to the white dwarf. The SU UMa subgroup have orbital periods less than 2 hours and show two sorts of outbursts. The ordinary outbursts are of lower amplitude then the super-maxima and are also more frequent although the super-maxima are more regular. He then discusses observations of white dwarfs which show short period, low amplitude variations. These objects have hydrogen in their spectra and define a new class of variable named ZZ Ceti stars after their prototype. This paper is followed by one by H. M. Van Horn who discusses non-radial oscillations in degenerate dwarfs as a possible explanation of these short period oscillations.

Overall, this book is interesting and useful although the price means that few individuals can be expected to buy a copy. It is, however, a necessary addition to any astronomical library. The quality of paper and binding is excellent as is normal with D. Reidel's IAU publications. The lack of an index is irritating although this is of less importance than usual due to the specificness of the sections and the useful summary tables within many of them. Basically this is a useful book for those people involved in the area discussed in it though it offers little to the general reader.

CHARLES A. WHYTE

Stars and Galaxies from Observational Points of View
Ed. E. K. Kharadze, D. Reidel Publishing Company, 1976, pp. 535, £20.00.

This book contains the proceedings of the 3rd European Astronomical Meeting held at Tbilisi in July 1975, attended by participants from nineteen European Countries though the majority were from the USSR. Principally, it was a conference to discuss the observational material existing on stars and galaxies, mostly obtained by traditional astronomical techniques, although some satellite results were reported.

There were three sessions on stars which consisted of 10 major papers and 23 short communications. These papers covered many fields including recent ultra-violet observations by Russian and Dutch satellites, the problem of automatically classifying stellar spectra, some comments on supernovae and a comparison of theoretical atmosphere models with observations and the determination of elemental abundances. There were also several reports on very young stellar objects, such as the T Tauri stars, and a common theme seemed to be that advances in the problem of star formation will come from observational work rather than theory.

The other 8 sessions were concerned with galaxies and consisted of 24 main papers and a host of shorter research notes. Among the topics covered were nuclear activity in galaxies and its relation to quasars and Seyfert galaxies, radio galaxies, the formation of galaxies in a cosmological framework, the fragmentation of galaxies and the origin of dwarf galaxies, like the two companion of the Andromeda galaxy. There were also several papers on the distributions and motions of subclasses of stars in our own galaxy and those galaxies close to us. Again there was some emphasis on newly-formed stars as tracers of galactic structure.

There was one session devoted entirely to the 'missing mass' problem and several pertinent observations were reported. These observations included infrared observations of halos round spirals, extended halos round elliptical galaxies and the diffuse X-rays sources usually associated with clusters of galaxies.

The main feature of these proceedings is the large number of papers given by members from the host country, which makes this book one of the few places where one can find a fairly comprehensive report on observational astronomy in the USSR.

The book has an author index but would have benefited more from a subject index as well, as there is no contents section which includes titles for the short communications. Like most proceedings, this one has been produced from author-prepared typescripts, though it is also illustrated with clear diagrams. Overall, there are many interesting papers but few astronomers will read all of it as the material covered is so diverse.

CHARLES A. WHYTE

India in Space
By Mohan Sundara Rajan, Govt. of India Publications Division, 1976, pp. 92, Rs. 5.00.

The Indian Space Research Organisation felt that laymen found it difficult to comprehend space technology; this volume sets out to overcome this difficulty and at the same time introduces India's space programme.

The author, a radio and television commentator in science and technology, displays his pride in his country's achievement and has produced a volume which should appeal to a wide audience. The early work on solid motors and the Rohini family of sounding rockets is described together with the facilities at Thumba.

Mr. Rajan is justly proud of the achievement of Aryabhata India's first satellite launched by the Soviet Intercosmos rocket in April 1975 and controlled from the Sriharikota Ground Station.

The SITE experimental TV transmission from ATS-6 is described and the possibilities for future experiments explored. The work carried out in collaboration with CNES in multiband and multistage aerial photography is described and the value of application satellites generally is discussed.

Finally, Mr. Rajan surveys some of India's pioneers in the field of space. A very readable work containing much of interest.

P. J. CONCHIE

NEXT MONTH

"In Search of the 10th Planet" is the challenging title of a special investigation by Anthony Lawton into recent discoveries within our Solar System. The arguments focus on a close encounter between a possible proto-system of Neptune and another planet ('X') which may have caused the projection of Pluto into a separate orbit around the Sun. Other articles in the March issue will include "A Ticket to Space," a new 'private venture' project in the United States described by Curtis Peebles; "The MKF-6 Multispectral Camera in Space," by Wilhelm Hempel, and further instalments of our popular series "Missions to Salyut 6" and "Where Are They Now?"

JBIS

Journal of the British Interplanetary Society

WE ARE SEEKING PAPERS for publication in future issues of *JBIS*, subject to our normal Editorial review procedure, on the following topics:

- **SPACE SCIENCE AND EDUCATION**
- **SPACE COMMUNICATIONS**
- **SATELLITE TECHNOLOGY**
- **INTERSTELLAR TRAVEL AND COMMUNICATION**
- **ASTRONAUTICS HISTORY**
- **CURRENT SPACE PROJECTS**
- **REMOTE SENSING**
- **ADVANCED TECHNOLOGY (APPLICATIONS)**
- **SPACE POWER SYSTEMS**
- **MATERIALS PROCESSING AND EXPERIMENTS IN SPACE**
- **ORBITAL DYNAMICS**
- **PROPULSION SYSTEMS**
- **SPACECRAFT CONTROL AND DATA PROCESSING**

CONTRIBUTIONS ARE INVITED FROM BOTH MEMBERS AND NON-MEMBERS on these and other related topics.

Illustrations line and half-tone preferably drawn or reduced to 82 mm, 142 mm and 178 mm wide for same-size reproduction.

REPRINTS may be obtained at nominal cost. Order forms are sent to authors with proofs.

CONTRIBUTORS SHOULD SUBMIT MATERIAL TO:

The Executive Secretary, The British Interplanetary Society, 12 Bessborough Gardens, London, SW1V 2JJ, England.

SHOULD YOU CHANGE YOUR ADDRESS

NOTIFY the Society before the 25th of the month: otherwise it will be too late to be incorporated in the dispatch instructions for the next month's magazine.

ASK the GPO to redirect your magazines etc.

DO NOT notify our Printers, nor write to our Dispatch Agents, for neither maintain addressing lists.

It is advisable to notify the Society of your intended removal one month beforehand, if at all possible.

BIS DEVELOPMENT PROGRAMME

WILL YOU HELP US WITH A DONATION

We thank all our members who have given so generously to our Development Appeal.

The total received, just before going to Press, was as follows:

TOTAL 30 NOVEMBER 1978 £28,988

In 1979 the Society's finances will be under very heavy pressure as payments become due for construction work and equipping the building. Every extra bit of income is important at the present time and any contribution which you feel able to make will be immediately applied to this urgent and vital work. Whatever you can give will definitely count. Please give generously.

These are just a few of the expressions of support which we have received from members:

I enclose a small gift towards the BIS Development Programme. I wish the amount sent could be larger, but I am still at school so only receive pocket money.

TONY COOK

Sounds like £25,000 was an underestimate! I enclose approx. 3% of this term's student grant. Not enough taking into account all the Society does.

SIMON COOPER

Enclosed is my first (£1) contribution to the Appeal. Unfortunately as a grantless (i.e. penniless) student this is more than I can afford at present.

More will follow soon, exam results and Denis Healey permitting.

JAMES ROWNTREE

Another thing I want to say is (and maybe you can publish it in *Spaceflight)* that if all the members of the BIS (about 3,000) would give only £20 to the Development Programme about half of the money you need would be there. Enclosed you will find £5 as my fourth contribution.

DANIEL VERCAMMEN

May I express my sincere hope that the Society achieves its aims both in the long and short term and congratulate (and thank!) you on doing an excellent job.

PAUL ZARUCKI

I recently gave a talk to a local "over 18 club" on General Astronomy. I enclose the £5 fee for the Society's Fund.

ROBERT BRUFFELL

Please send your gift to:

EXECUTIVE SECRETARY, MR. L. J. CARTER

BRITISH INTERPLANETARY SOCIETY

12 Bessborough Gardens, London, SW1V 2JJ.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

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Correspondence and manuscripts intended for publication should be addressed to the Editor 12, Bessborough Gardens, London, SW1V 2JJ.

Opinions in signed articles are those of contributors, and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Short Paper Evening

Title **EXOTIC SEMI–CONDUCTOR MATERIALS**
by A. T. Lawton

Title **INTERSTELLAR COLONISATION**
by Dr. L. J. Cox

To be held in the Kent Room of Caxton Hall, Caxton Street, London, S.W.1. on **1 February 1979,** 6.30-8.30 p.m.

Admission tickets are not required. Members may introduce guests.

Visit

Arrangements are being made for a small party of members to visit the Propellants Explosives & Rocket Motor Establishment (PERME) at Westcott, Nr. Aylesbury, Bucks. on **14 February 1979** *(all day).*

The excursion will be by train to and from Aylesbury (departure Marylebone Station).

Registration is necessary. Members interested in participating *must* apply to the Executive Secretary, enclosing a **reply-paid envelope** no later than **28 January 1979.**

Western Branch

Topic **FILM SHOW**

To be held in the Physics Lecture Theatre, G.4Z, Tyndalls Avenue, University of Bristol, on **2 March 1979** at 7.15 p.m.

The programme will be as follows:

(a) Remote Possibilities

(b) The Weather Watchers

(c) If One Today, Two Tomorrow

(d) The Mission of Apollo Soyuz

Admission tickets are not required. No University car parking facilities are available but there are Public Car Parks at Park Row, Berkeley Place and limited road parking around the University.

General Meeting

Title **SPACE MISCELLANY – 2**

To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **8 March 1979** 6.30-8.30 p.m.

Two contributions will be presented:

(1) Phil Parker will travel down memory lane with Apollo Reminiscences.

(2) David Early will discuss and exhibit some of his Space Paintings

Members interested in presenting short contributions to later meetings of this nature are invited to send details to the Executive Secretary.

Admission tickets are not required. Members may introduce guests.

Lecture

Title **ASTRONOMY FROM ORBIT**
by Dr. W. I. McLaughlin *(J.P.L.)*

To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **4 April 1979,** 6.30-8.30 p.m.

Admission tickets are not required. Members may introduce guests.

3rd BIS CONFERENCE ON INTERSTELLAR STUDIES

To be held in the Chemistry Lecture Theatre, University College London, Gordon Street, London, W.C.1., on Wednesday and Thursday, **11-12 September 1979**. (Note change in dates).

The scope of the Conference is intended to cover all aspects of Interstellar Studies, including such topics as:

- Propulsion concepts
- Interstellar probes
- Extra-solar planetary systems
- Laser and radio communication
- Evolution of life
- Rise of intelligence and civilisation

It is planned to allow ample opportunity for discussion to take place among the participants, both informally and in final discussion sessions.

Papers presented at the Conference will be published in the Interstellar Studies issues of *JBIS*, following usual reviewing procedures.

Applications for registration forms and notification of the intention to submit a paper for the Conference, should be made to: The Executive Secretary, British Interplanetary Society, 12 Bessborough Gardens, London, SW1V 2JJ, England.

16th EUROPEAN SPACE SYMPOSIUM

Theme: **CURRENT AND POTENTIAL EUROPEAN SPACE PROJECTS**

To be held in Stresa, Northern Italy, on 3rd - 5th July, 1979, co-sponsered jointly by the DGLR, AAAS, AIDAA and BIS.

Technical Sessions will be devoted to the following main subject areas.

(1) Spacelab and Supporting Activities

(2) Technology of Space Vehicles (Satellites and Launchers)

(3) Space Applications

(4) Future Trends

Offers of Papers are Invited. Please contact the Executive Secretary for further information.

Programmes and Registration forms will be available on request in due course.

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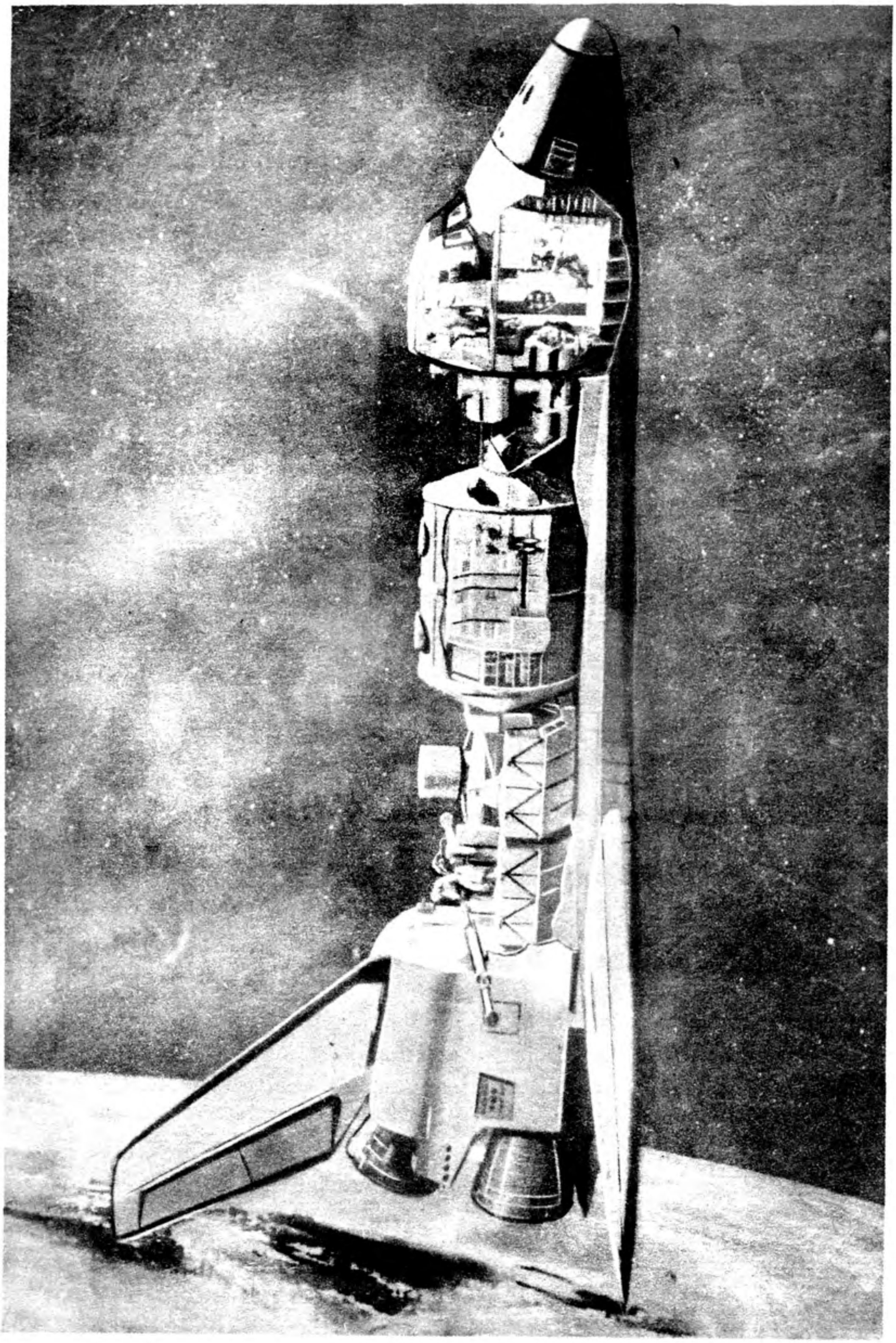


BIS DEVELOPMENT PROGRAMME

PROGRESS REPORT – 8

Quite a remarkable change has taken place in the appearance of the Society's new Headquarters building since the last Report. The removal of the hoarding facing No 27 and the erection of the front railings transformed the appearance of the building. One was even able to squeeze in through the aperture which was soon to become the front door, though this was by no means an easy feat for the clearance was only 12" and one faced building work in progress immediately on the other side. However, the mere ability to use what will be the front door, for the very first time, made it something in the nature of a red letter day.

For the first time, too, the work of the electricians produced a blaze of light which enabled workmen to continue their task in spite of the early closing darkness.

Much of the external work has now been completed. The new roof, frontage, the connecting "link," the windows, and now even one half of the front railings, all serve to give it a "polished" look. Admittedly, the rest of the railings still have to go in, and the front door too.

Internally, much remains to be done but the workmen from the secondary trades have already begun and things are moving apace. New plastering is beginning to give a smooth appearance to the walls and ceilings even though, for some inexplicable reason, electricians appear to be gouging out great chunks elsewhere in order to bury their wiring, this making the description of either "ordered chaos" or simply "chaos" something of a fine point.

The stairway has been made much safer by the inclusion of some of the banisters, though counter-balanced by boarding and ladders in strategic positions to enable plastering to be continued and which intermittently block the way, so personal agility is still much in demand.

The internal door spaces are rapidly being fitted with frames, and even with doors themselves, though elsewhere a pneumatic drill showed that the final hole had still to be punched to create an aperture for the final door to be fitted in position. Skirting boards were being put rapidly into place and even receiving a first lick of paint.

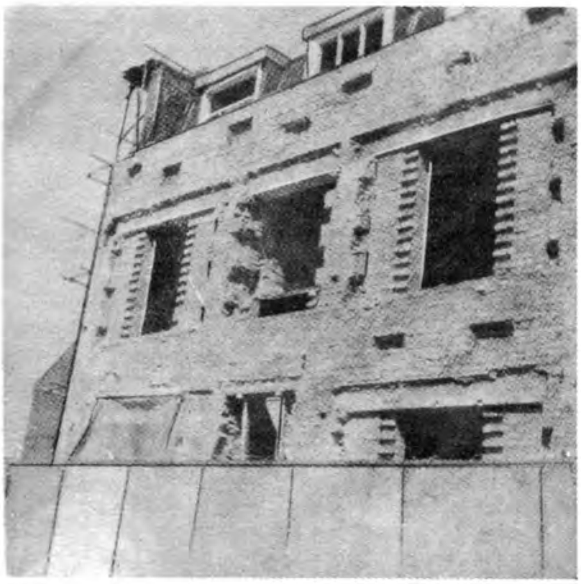
Another noteworthy event was that the building received its first two visitors, namely Jim Harford, Executive Secretary of the AIAA and Miss Mireille Gerard, Director of the International Affairs Office of the AIAA, both of whom accompanied the Executive Secretary on a tour of the various rooms, no doubt on the basis that all Secretaries are expendable and their loss in any mishap would go unnoticed. Both, however, expressed themselves agreeably surprised at the mammoth task being undertaken by the Society, possibly tempered by relief at getting out again in one piece, the latter being made more difficult by the appearance of a deep trench cunningly laid across the exit point, ostensibly to hold the foundations for the loos which will be built later for the convenience of members attending meetings in the Conference Room.

With all the current archaeological interest around, one would have assumed that some old coins would have turned up during the digging, but if they did, no-one owned up.

An added attraction in cold winter days was the appearance of a boiler, due to be fitted into the basement to provide a modicum of central heating, the more ambitious scheme modelled on normal American practice having been jettisoned early on in view of the high cost involved. However, this, and a warm fire nearby created from burning odd chunks of wood and similar combustible debris, together with the newly-won electric lighting, all combined to reduce the teeth-chattering and general shivering to enable one to complete these notes.

There were, however, clouds on the horizon in quite another sense from those which had converted the rear of the premises into a quagmire. This took the form of complaints from the Builders that all the extra work had put them behind and, like the cuckoo, they were thinking of premises ready for occupation in the Spring!

Meanwhile, steps were initiated to change our address in all the Directories and Works of Reference.



THEN and NOW – Two contrasting pictures showing progress of the work on the front facade of the Society's new HQ building, in July 1978 (*left*) and January 1979 (*right*) respectively.

SPACEFLIGHT

A Publication of The British Interplanetary Society

Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

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CONTENTS

COVER

SPACELAB. America's Space Shuttle is scheduled to carry the European space laboratory in the 1980's to begin an important new series of space studies in science and technology. The results could revolutionise many aspects of biology, medicine, astronomy and astrophysics, metallurgy and the processing of materials for wide industrial applications. This drawing shows one configuration of Spacelab with a large pressurized module and two instrument pallets. Cut away in the nose of the Shuttle Orbiter can be seen the crew compartment for U.S. astronauts (commander/co-pilot and mission specialist) and underneath the sleeping, dining, washing, toilet and other facilities for the entire crew and payload specialists. An interconnecting tunnel links Spacelab with this section.

ERNO Raumfahttechnik GmbH

MILESTONES

November

28 Second static test of Ariane launcher's cryogenic third stage in flight configuration at Société Européennee de Propulsion (SEP) facilities, Vernon, France, is interrupted following an ignition failure of the H8 engine. Slight explosion damages propulsion bay but not the test stand. Effects on development timetable are to be studied. The target – to make Ariane operational in 1981 – is unaffected but first test launch of Ariane at Korou, set for July 1979, may be delayed.

December

1 First day of Global Atmospheric Research Programme (GARP) coordinated by World Meteorological Organisation (WMO) in Geneva. During next 12 months, programme will involve: 9,200 land-based stations: 7,000 ships; 80 scheduled aircraft; 5 geostationary satellites and 4 satellites in polar orbits, and hundreds of buoys and balloons. First trial group of balloons floating at altitude of 14 km are tracked by satellite. Some are found to circle the Earth driven by strong wind currents.

4 Pioneer Venus 1 is braked into orbit around Venus with the object of studying the planet for at least one Venerian year. Discovered that upper atmosphere at some 50 miles (80 km) altitude is 40 deg F (4.4 deg C) warmer at the planet's poles than at its equator. At periapsis, the orbiter dips as low as 93 miles (150 km) from the surface. Apart from sampling composition of upper atmosphere, craft makes radar measurements of surface elevations and roughness. It also takes UV and IR pictures of the planet's thick clouds.

5 Liquid oxygen heat exchanger fails during test of Space Shuttle Main Engine at National Space Technology Laboratories, Bay St. Louis, Miss. Component, which was badly damaged, has the function of converting LO_2 to gaseous oxygen to pressurize the Orbiter's external propellant tank.

5 Fourth development test in flight configuration of Ariane launcher L.140 first stage is successfully carried out at Société Européenne de Propulsion (SEP), Vernon, France. Static test lasted 142.9 secs – continuing to depletion of N_2O_4 propellant, thereby confirming proper function of propulsion system for stage's nominal thrust duration of 142.5 secs.

6 British Aerospace announces that first Spacelab pallet scheduled to fly aboard NASA Space Shuttle has been despatched from Stevenage space facility to ERNO in West Germany for onward shipment to Kennedy Space Center.

9 Four instrument probes separated from Pioneer Venus 2 in November penetrate atmosphere of Venus; mothercraft burnt up in atmosphere as planned. Mission is rated highly successful. All the probes operated from entry to impact and, unexpectedly, the Day probe survived for 67 minutes on the surface. Landings by the four probes were confirmed at the following times: 700 lb (317 kg) sounder probe 11.43 a.m. PST, and the 200 lb (90.7 kg) North, Day and Night probes at 11.46, 11.51 and 11.55 respectively. Data analysis "will take several weeks." Clouds not only contain unexpectedly large amounts of sulphuric acid but particles of free sulphur; some 40 times as much of the rare gas argon than in Earth's atmosphere is detected. With external temperatures 900 deg F (482 deg C), one probe registered internal heat of 260 deg F (126.7 deg C). Atmosphere was so dense that probes slowed to 25 mph (40 km/hr) as they reached the surface.

[Continued overleaf

12-22 Engineering mock-up of triple payload for third test flight (LO3) of the European launcher Ariane in May 1980 undergoes vibration testing on CNES facilities at Toulouse Space Centre. Payload comprises: 1. Ariane Technological Capsule (Capsule Ariane Technologique) – CAT, which is flown on all Ariane test flights; 2. Apple, the technological satellite of the Indian Space Research Organisation (ISRO), which will carry a communications experiment; and 3. Meteosat 2, ESA's second meteorological satellite. Apple and Meteosat 2 will be the first two satellites placed in Clarke (geostationary) orbit by a European launcher. Was the first time that such a heavy and bulky payload had been tested in Europe, the complete composite being 6.5 metres high and weighing 1,574 kg.

18 NASA announces that efforts to reboost or deboost the 77-ton Skylab space station are being discontinued because of uncertainties which have developed in Skylab systems, Skylab lifetime, Space Shuttle schedule and Teleoperator Retrieval System (TRS) delivery. Problems are detailed as follows: 1. Deterioration of systems aboard Skylab, e.g. recurring control moment gyro anomalies, marginal power conditions and minimal attitude control gas. 2. Sunspot activity in recent months has been high, accentuating Skylab's decay from orbit. 3. Detailed reviews showed that TRS mission on the second Space Shuttle flight would be difficult to accommodate prior to April 1980. NASA predicts that "Skylab will re-enter the atmosphere between mid-1979 and mid-1980. Most of the vehicle will burn up during re-entry but it is expected that some fragments will reach the surface. Its flight path is 75 per cent over the ocean. Probability of injury or damage is less than that from meteorites, according to estimates."

19 Soviets launch Gorizont (Horizon) 1 communications satellite into orbit of 22,581 x 48,365 km inclined at 11.3 deg to equator. Three-axis stabilised spacecraft will relay television, telephone and radio services.

19 Radio Moscow announces that Venera 12, launched 14 September, released an experimental module with the object of soft-landing on Venus.

19 In a joint Franco-Soviet experiment planned for 1983-84, Dr. Jacques Blamount announces plans to explore the upper region of Venus's atmosphere with a pair of 27 ft (8.3 metre) diameter balloons which will break out and inflate from a split, spherical canister to be ejected from a Soviet spacecraft. Released from the canister at a height of 37 miles (59.5 km), they will drop another 7 miles (11 km) before becoming fully inflated. They are then expected to drift up to a "cruising height" of some 35 miles (56 km) to enable instruments to explore the planet's sulphuric clouds for a period of weeks or months.

21 Capsule ejected from Venera 12 soft-lands on sunlit side of Venus, continues to send information for some 110 minutes. Television pictures, sent *via* parent spacecraft on fly-by mission, show a flat, rocky landscape (unconfirmed report – Ed.).

23 Landing module separates from Venera 11.

25 Module ejected from Venera 11 fly-by spacecraft soft-lands on Venus. Transmits surface information for some 95 minutes.

27 *Tass* reports that landing modules of Venera 11 and 12 landed some 800 km (497 miles) apart. Enormous quantity of data obtained from both probes. Instruments detected presence of key argon isotopes during descent phase, argon 40 and argon 56, in 200 times the proportions found on Earth. Surface pressures were about 88 atmospheres, temperature 466 deg C. Mother craft are continuing on their respective paths, reporting conditions in near-Venus space; Venera 12 parent also conducting a Franco-Soviet programme of research into solar and galactic gamma rays.

27 Space Shuttle Main Engine on test at National Space Technology Laboratories, Bay St. Louis, is engulfed by fire, apparently due to failure of engine main oxidizer valve after engine had run for 255 sec of planned 520 sec full-duration test at full power. First launch of Space Shuttle at Kennedy Space Center may be delayed beyond 28.9. 1979.

27 NASA announces that an informal agreement has been reached in principle on U.S.-Chinese cooperation in the development of the civil communications system of the People's Republic of China: "This involves the purchase by China of a U.S. satellite communications system, including the associated ground receiving and distribution equipment. The space portion of the system will be placed in geostationary orbit by the United States, with continued operation to be carried out in China. Similar informal agreement has been reached regarding the purchase by China of a ground station capable of receiving Earth resources information from U.S. Landsat remote sensing satellites, including the Landsat-D now under development." The statement followed joint discussions of a delegation from the People's Republic of China and United States officials which opened in Washington on 28 November regarding possible U.S.-Chinese cooperation in the "peaceful utilization of space technology." The U.S. delegation was headed by Dr. Robert A. Frosch, NASA Administrator, the Chinese delegation by Dr. Jen Hsin-min, Director of the Chinese Academy of Space Technology. The Chinese delegation visited several NASA centres and U.S. aerospace industrial establishments.

January

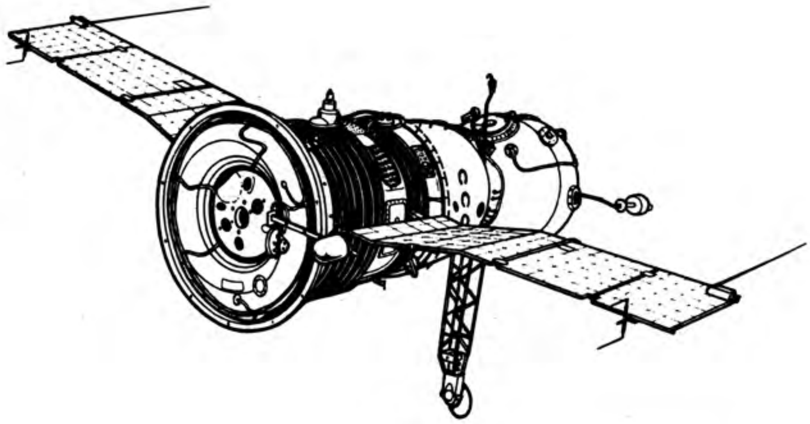
1 NASA gives status of Voyager 1 spacecraft as follows: Distance from Earth 598,975,000 km; one-way communications time 33.3 min; distance to Jupiter 62,381,000 km; distance to Saturn 891,356,000 km; distance travelled since launch 931,872,000 km; velocity relative to Earth 70,830 km/h; velocity relative to Sun 49,262 km/h; date of Jupiter encounter 5 March 1979; date of Saturn encounter 12 November 1980. Status of Voyager 2: distance from Earth 544,445,000 km; one-way communications time 30.2 min; distance to Jupiter 134,393,000; distance to Saturn 888,486,000 km; distance travelled since launch 936,428,000 km; velocity relative to Earth 68,537 km/h; spacecraft velocity relative to Sun 44,334 km/h; date of Jupiter encounter 9 July 1979; date of Saturn encounter 27 August 1981.

A CLASSIFICATION OF SOYUZ VARIANTS

By Nicholas L. Johnson*

Introduction

The Soyuz spacecraft has been the mainstay of the Soviet man in space programme since 1967. As with any other product of high technology many improvements and alterations have been incorporated in this vehicle during the past several years. However, a procedure for classifying new Soyuz spacecraft has been hampered by the varied missions undertaken. Initially employed in Earth orbit as a test and research vehicle, Soyuz has also served as a space station ferry, an Earth resources spaceship, and in conjunction with the Apollo-Soyuz Test Project (ASTP).



Early example of Soyuz spacecraft with extensible solar panels and toroidal fuel tank.

From "Frontiers of Space" by P. Bono and K. W. Gatland, Blandford Press Ltd.

Soyuz Variants

Anyone who has followed the Soviet manned Soyuz space programme is acutely aware of the many operational versions of Soyuz which have appeared since the first Soyuz flew as Cosmos 133 in November, 1966. To illustrate the situation one need only consider the Soyuz 10 and 12 spacecraft in comparison with Soyuz 1. Soyuz 10 was the first manned Soyuz to dispense with the toroidal fuel tank at the aft end of the spacecraft. By the flight of Soyuz 12 the characteristic solar panels had also been removed and the command module capacity was reduced from three to two cosmonauts.

The necessity of these Soyuz variants has arisen from the wide variety of manned and unmanned missions imposed upon the Soyuz spacecraft and, in the case of the last mentioned alteration, from deficiencies in spacecraft design [1]. A number of attempts have been made to categorize the differences in Soyuz configurations [2]. However, for the most part these classifications were not meant to be formal and have proved to be unwieldy or over simplified.

That this problem of classification of Soyuz spacecraft is of vital interest is witnessed by the sometimes lively debates pursued in the pages of *Spaceflight* concerning the structural characteristics of Soyuz spacecraft as a clue to their specific missions. Indeed, there is still heated discussion as to whether Soyuz was originally intended to be used as part of a larger lunar spacecraft or has always been planned as merely an Earth orbital vehicle.

However, despite the resolution of the intended role of Soyuz, this second generation spacecraft has served a number of Earth orbital missions - each with its own peculiar requirements for spacecraft capabilities. The purpose of this paper, therefore, is to define the criteria needed to construct a concise, useable classification of Soyuz spacecraft and to propose such a system.

The first difficulty encountered in this process is setting forth those differences in Soyuz spacecraft which warrant distinction. For example, although few will question the need to distinguish between those Soyuz propulsion modules which carry solar panels from the wingless variety, is it necessary to maintain separate clsssifications of the 3-segmented and 4-segmented solar panels?

As a major criterion to establish a category of classification a particular modification must successfully answer the question: "Does this modification *significantly* affect the performance capabilities of the Soyuz spacecraft?". To do otherwise would quickly snowball the classification with needless groupings into an unmanageable system.

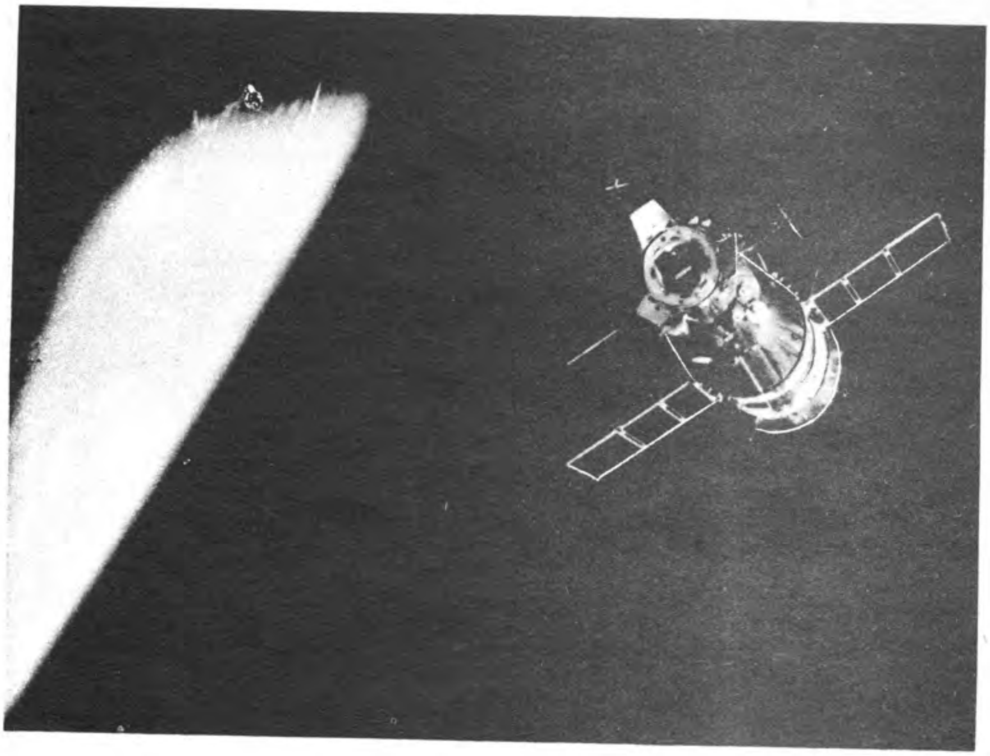
Uncommon Design Features

In the above examples, the presence of solar arrays extends the operational life of a manned Soyuz from 2-3 days to 30 days, which in turn greatly expands the limits of a Soyuz mission. However, the switch from the 4-segmented wing-like solar panels to the shorter, flatter 3-segmented solar panels does not significantly degrade the capabilities of Soyuz, and thus does not demand separate designation.

Secondly, one must consider the modular nature of the Soyuz spacecraft. Soyuz can be virtually mass-produced since the three modules (orbital, command, propulsion) which comprise the spaceship are largely independent from one another and may be modified without significantly affecting the remaining modules. The failure to analyze Soyuz as a composite vehicle has led to numerous "versions" of Soyuz and has hindered simple descriptions of the spacecraft which many times can be used to indicate the nature of the space mission. Hence, the major variants of each module must be considered separately.

The orbital module presents the greatest challenge to classification. Although many basic systems are common to all orbital modules (e.g. life support, food storage, sanitation, berthing, etc.) each orbital module is redesigned internally to fit the mission requirements. The orbital compartment as a whole serves one of two primary functions: as an Earth orbiting laboratory or as a crew transfer/supply module. In the former mode, the orbital module can be arranged to provide simple cosmonaut needs for extended periods of

* *Staff, U.S. Naval Nuclear Power School, Naval Training Center, Orlando, Florida, USA.*



The Soyuz variant involved in the Apollo-Soyuz Test Project of 1975, as photographed from Apollo (see page 103).

National Aeronautics and Space Administration

time (Soyuz 9) or to carry specific large scientific experiments (Soyuz 6, Soyuz 13, Soyuz 22). In these configurations, no docking or crew transfers are needed or possible.

If docking and crew transfer do form a part of the mission agenda, a docking collar and egress capability are provided. Here the orbital module has undergone several evolutionary changes. With the exception of Soyuz 6 all Soyuz through Soyuz 8 carried either a probe or drogue type docking collar to ensure a firm mechanical and electrical connection between two Soyuz spacecraft. But in these early models of Soyuz, the docking mechanisms were rigid and could not be removed to allow internal transfer of crew members. Thus, during the Soyuz 4-5 flight, after docking Khrunov and Yeliseyev had to don spacesuits and perform an extra-vehicular activity (EVA) from Soyuz 5 to Soyuz 4.

Almost two and one half years later, the Soyuz 11 cosmonauts utilized an improved docking mechanism which allowed them to enter the Salyut 1 space station without venturing into space by removing the probe/drogue arrangement after docking. This technique has been used on all Soyuz-Salyut missions to date. Finally, on Soyuz 16 and Soyuz 19 the new international androgynous docking collar was tested. Internal crew transfer is still allowed and the bulky probe/drogue has been eliminated. An added advantage with this newest system is that there is no longer any need to build two different spacecraft - one probe-carrying and one with the drogue. Now all spacecraft employing an androgynous docking mechanism are compatible and can dock together.

Hence, the presence and type of docking mechanism on an orbital module is the prime factor in determining its function on any flight. Table 1 lists the possible variations and provides a designator for use in an overall Soyuz classification. No designator has been provided for a removable drogue since this apparatus is used exclusively by Salyut space stations and has never been flown by a Soyuz. Note also that provision has been made for the absence of the orbital module entirely. As will be shown later this was the case during the Zond circumlunar programme and other test flights.

The command module of Soyuz has thus far undergone only one major redesign effort. Basic instrumentation and equipment has not changed substantially since Soyuz 1, but crew size has. Soyuz 1 through Soyuz 11 had the capacity to carry three cosmonauts in a shirt-sleeve environment. However, following the fatal accident of Soyuz 11, the third cosmonaut couch was replaced by spacesuit support equipment to allow the remaining two cosmonauts to wear spacesuits during launch, docking, and recovery.

Table 2 illustrates the four possible configurations of the Soyuz command module. The last configuration which provides for three cosmonauts in spacesuits is included due to the expectation of this new variation in the near future, and its possible test by Cosmos 869 [3, 4]. Again provision has been made for the absence of the command module for the unmanned testing of other Soyuz components discussed later in this paper.

The last compartment to be considered is the propulsion module. Depending upon the missions requirements and weight restrictions, only four variations of the propulsion module have flown. Soyuz 1 through Soyuz 9 all carried the wing-like solar panels and the additional toroidal fuel tank. After Soyuz 9 and the apparent abandonment of the Soviet manned lunar landing programme, all propulsion modules on manned Soyuz flights have omitted this fuel tank. This fuel capacity reduction seriously affects the potential of the Soyuz spacecraft for orbital and rendezvous manoeuvres [5].

The first manned wingless Soyuz flew as Soyuz 12, but since then at least four manned and four unmanned missions have reverted back to the solar panels. The four configurations of propulsion modules are given in Table 3.

Three-digit Designator

By taking the three Soyuz modules as a whole a three-digit designator can be applied to any Soyuz spacecraft. The three digits are arranged in order of the vehicle configuration: the first representing the orbital module, followed by the command and propulsion modules' designators, respectively. Thus the standard Soyuz ferry to Salyut space stations is a

TABLE 1. Orbital Module Variants

Designator	Configuration
0	No orbital module present.
1	No docking mechanism present.
2	Non-removable probe.
3	Non-removable drogue.
4	Removable probe.
5	Androgynous docking mechanism.

TABLE 2. Command Module Variants

Designator	Configuration
0	No command module present.
1	Three-seat capacity, no spacesuits.
2	Two-seat capacity with spacesuits.
3	Three-seat capacity with spacesuits.

TABLE 3. Propulsion Module Variants

Designator	Configuration
1	Solar panels, toroidal fuel tank.
2	No solar panels, toroidal fuel tank.
3	Solar panels, no toroidal fuel tank.
4	No solar panels, no toroidal fuel tank.

TABLE 4. Soyuz Programme Variants

Soyuz	Type	Date Launched	Days in Orbit	Mission Performed
1	2/1/1	23 Apr 67	1	First manned Soyuz test.
2	3/1/1	25 Oct 68	3	Unmanned target for Soyuz 3.
3	2/1/1	26 Oct 68	4	Rendezvous with Soyuz 2.
4	2/1/1	14 Jan 69	3	Rendezvous and docking with Soyuz 5.
5	3/1/1	15 Jan 69	3	Rendezvous and docking with Soyuz 4; EVA crew transfer.
6	1/1/1	11 Oct 69	5	Research and triple rendezvous with Soyuz 7 and 8.
7	3/1/1(1)	12 Oct 69	5	Triple rendezvous with Soyuz 6 and 8.
8	2/1/1(1)	13 Oct 69	5	Triple rendezvous with Soyuz 6 and 7.
9	1/1/1	1 Jun 70	18	Long duration research.
10	4/1/3	23 Apr 71	2	Rendezvous and docking with Salyut 1; Crew transfer failed.
11	4/1/3	6 Jun 71	24	Rendezvous and docking with Salyut 1.
12	4/2/4	27 Sep 73	2	Test flight.
13	1/2/3	18 Dec 73	8	Research.
14	4/2/4	3 Jul 74	16	Rendezvous and docking with Salyut 3.
15	4/2/4	26 Aug 74	2	Failed to dock with Salyut 3.
16	5/2/3	2 Dec 74	6	ASTP test flight.
17	4/2/4	10 Jan 75	30	Rendezvous and docking with Salyut 4.
18A	4/2/4	5 Apr 75	0	Launch aborted.
18B	4/2/4	24 May 75	63	Rendezvous and docking with Salyut 4.
19	5/2/3	15 Jul 75	6	ASTP mission.
20	4/2/4	17 Nov 75	91	Rendezvous and docking with Salyut 4; unmanned long duration test.
21	4/2/4	6 Jul 76	49	Rendezvous and docking with Salyut 5.
22	1/2/3	15 Sep 76	8	Research
23	4/2/4	14 Oct 76	2	Failed to dock with Salyut 5.
24	4/2/4	7 Feb 77	18	Rendezvous and docking with Salyut 5.
25	4/2/4	9 Oct 77	2	Failed to dock with Salyut 6.
26	4/2/4	10 Dec 77	38	Rendezvous and docking with Salyut 6.
27	4/2/4	10 Jan 78	65	Rendezvous and docking with Salyut 6.
28	4/2/4	2 Mar 78	8	Rendezvous and docking with Salyut 6.
29	4/2/4	15 Jun 78	81	Rendezvous and docking with Salyut 6.
30	4/2/4	27 Jun 78	8	Rendezvous and docking with Salyut 6.

(1) Soyuz 7 may have been a 2/1/1 Soyuz (active) while Soyuz 8 was a 3/1/1 Soyuz (passive).
Note: All Tables in this paper cover the time period Nov 1966 - Jun 1978.

4/2/4 Soyuz, while Leonov and Kubasov flew a 5/2/3 Soyuz during the Apollo-Soyuz Test Project.

Table 4 is a list of all Soyuz programme vehicles by mission and type of spacecraft. A brief study of the chart indicates that the value of this classification system is simplicity. In a time when the number of spacecraft under the Soyuz label has just reached 30 and the number under the Cosmos label (*not* including military surveillance satellites) is close to that, memorizing the missions of each flight is similar to memorizing all the Presidents of the United States by their terms of office or the reigns of the Kings and Queens of England. However, by noting that Soyuz 22 was a 1/2/3 Soyuz, one immediately recognizes that this was an Earth orbital research mission with no docking collar, utilizing solar panels; whereas Soyuz 23, which was launched exactly one month later, was a wingless ferry to a Salyut space station as evidenced by its 4/2/4 Soyuz designator.

Due to the need to keep the classification manageable a Soyuz designator cannot reveal all aspects of the missions, but only major capabilities. For instance, Soyuz 6 only carried two cosmonauts even though the command module was of the older three man capacity cabin and was involved in the Soyuz 6-7-8 rendezvous even though it could not dock.

Under this classification system the Zond 4-8 circumlunar test vehicles would be designated as having employed a 0/1/3 Soyuz [6]. Although the command modules during these flights carried a new large parabolic antenna and what appears to be a docking collar, a need does not exist to create a special command module designator since these components aided but were not essential to the mission and since no other spacecraft have been identified as consisting only of command and propulsion modules. The 0/1/3 designator immediately classifies the spacecraft as a "lunar Zond" of which the parabolic antenna and docking collar were characteristic.

Soyuz spacecraft also have flown many times under the Cosmos label, usually as a test of new on board systems. Those suspected Soyuz spacecraft in this category appear in Table 5. Together with the Zond 4 through Zond 8 flights, Table 5 indicates that almost as many Soyuz have been flown unmanned as manned. This underscores the Soviet practice of testing and man-rating major new systems first under automatic conditions even 10 years after Soyuz was first introduced.

Table 6 is a further analysis of Soyuz variants indexed by type. In all 12 versions of Soyuz are thought to have made flights. Interestingly enough, only four of these variants (2/1/1, 3/1/1, 4/2/4 and 5/2/3) have flown in both manned and unmanned modes. However, that statistic is deceiving. Two of the three manned variants which were never pre-

TABLE 5. Cosmos Programme Soyuz Variants

Cosmos	Type	Date Launched	Days in Orbit	Mission Performed
133	2/1/1	28 Nov 66	2	Test for manned flight.
140	2/1/1	7 Feb 67	2	Test for manned flight.
146	0/1/3(1)	10 Mar 67	8	"Lunar Zond" test flight.
154	0/1/3(1)	8 Apr 67	2	"Lunar Zond" test flight.
159	0/0/2	16 May 67	3832?	Propulsion module test.
186	2/1/1	27 Oct 67	4	Automatic rendezvous and docking with Cosmos 188.
188	3/1/1	30 Oct 67	3	Automatic rendezvous and docking with Cosmos 186.
212	2/1/1	14 Apr 68	5	Automatic rendezvous and docking with Cosmos 213.
213	3/1/1	15 Apr 68	5	Automatic rendezvous and docking with Cosmos 212.
238	2/1/1(2)	28 Aug 68	4	Retest after Soyuz 1 accident.
379	0/0/1(3)	24 Nov 70		Possibly related to lunar propulsion systems test.
398	0/0/1(3)	26 Feb 71		Possibly related to lunar propulsion systems test.
434	0/0/1(3)	12 Aug 71		Possibly related to lunar propulsion systems test.
496	4/2/3	26 Jun 72	6	Retest after Soyuz 11 accident.
573	4/2/4	15 Jun 73	2	First test of 2-man CM and wingless ferry.
613	4/2/4	30 Nov 73	60	Long duration test flight.
638	5/2/3	3 Apr 74	10	ASTP test flight.
656	4/2/4?	27 May 74	2	Possible test of automatic rendezvous and docking equipment.
670	4/2/3?	6 Aug 74	3	?
672	5/2/3	12 Aug 74	6	ASTP test flight.
772	4/2/4?	29 Sep 75	3	Possible test of greater battery capacity for wingless ferry.
869	4/3/3(4)?	29 Nov 76	18	Possible test of 3-man command module; See footnote (4).

(1) May have also carried toroidal fuel tank (0/1/1 Soyuz).
(2) Cosmos 238 may have been a 3/1/1 Soyuz and the target for a Soyuz 2-3 type mission which was cancelled after Cosmos 238 was in orbit.
(3) Presence of solar panels is uncertain (possible 0/0/2 Soyuz).
(4) An alternate theory of the mission of Cosmos 869 is that of prototype of the automatic Salyut space supply ferry, Progress. Its orbital characteristics, duration, and time of launch (ten months before the launch of Salyut 6) all point in this direction. Although Cosmos 869 appears to have been equipped with solar panels whereas Progress is not; these panels could have been used only for this test flight since the mission lasted eighteen days (normally Progress docks with Salyut within two days and then relies upon the space station's electrical supply).
Note: Cosmos 382 is often associated with the Cosmos 379, 398 and 434 flights or with a Salyut prototype. However, its orbital characteristics are significantly different from these flights. Thus, in the absence of any verifying data that Cosmos 382 was indeed a Soyuz variant, the spacecraft is deleted from this list.

tested in a Cosmos flight were employed on research missions in which the unneeded docking mechanism was replaced by other equipment (1/1/1 and 1/2/3 Soyuz). The remaining Soyuz variant, the 4/1/3 Soyuz, was the original Salyut ferry used on the Soyuz 10 and Soyuz 11 spaceflights. In the case of the Soyuz 10 mission lack of unmanned testing may have had a direct effect on the inability of the crew to transfer to Salyut 1 after docking.

On the other hand, there are five Soyuz variants which have been tested only under the Cosmos disguise. Two of the five were actually only propulsion module tests. The first was an early test of the propulsion module capabilities by Cosmos 159 (0/0/2 Soyuz) in 1967. Two more of these variants, the 0/0/1 and 0/1/3 Soyuz, are believed to be directly related to the Soviet lunar landing programme which was indefinitely postponed in the early 1970's. A 4/2/3 Soyuz appears to have been flown by Cosmos 496 and Cosmos 670. The former was the first test of the two-seat command module, while the latter's mission is more obscure. The three-day flight of Cosmos 670 marked a return to the use of solar panels for other than the ASTP flight then under development, and for the first time an orbital inclination of

TABLE 6. Soyuz Variants by Type

Soyuz Type	No. Flown	First Flown	Last Flown	Remarks
2/1/1	9	1966, Cosmos 133	1969, Soyuz 8	First Soyuz configuration. Probably related to lunar landing programme; terminated with cancellation of same programme.
0/1/3	7	1967, Cosmos 146	1970, Zond 8	"Lunar Zond"; terminated with cancellation of circum-lunar programme; never flown manned.
0/0/2	1	1967, Cosmos 159		Propulsion module test.
3/1/1	5	1967, Cosmos 188	1969, Soyuz 7	Docking target for 2/1/1 Soyuz.
1/1/1	2	1969, Soyuz 6	1970, Soyuz 9	Early research configuration.
0/0/1	3	1970, Cosmos 379	1971, Cosmos 434	Possible lunar propulsion system test; never used on manned flight.
4/1/3	2	1971, Soyuz 10	1971, Soyuz 11	Original Salyut ferry; both solar wings and third crew member eliminated after Soyuz 11 accident.
4/2/3	2?	1972, Cosmos 496	1974, Cosmos 670?	Systems test flight; never flown manned.
4/2/4	20	1973, Cosmos 573	1978, Soyuz 30	Current standard Salyut ferry.
1/2/3	2	1973, Soyuz 13	1976, Soyuz 22	Current research configuration.
5/2/3	4	1974, Cosmos 638	1975, Soyuz 19	ASTP variant.
4/3/3	1?	1976, Cosmos 869?		Possible test of return to three-man command module.
12 Types	58 Total			

Fig. 1. Number of Soyuz Variants by Type and Year

SOYUZ TYPE	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
4/3/3											1		
5/2/3									3	1			
1/2/3								1			1		
4/2/4								3	3	5	2	3	4
4/2/3							1		1				
4/1/3						2							
0/0/1					1	2							
1/1/1				1	1								
3/1/1		1	2	2									
0/0/2		1											
0/1/3		2	3	1	1								
2/1/1	1	3	3	2									

50.6 degrees was flown.

The final Soyuz variant which might have been already tested, but yet manned, is the 4/3/3 Soyuz. Cosmos 869 is thought by some to have been of this type. Regardless, one may expect to see a return to the three-seat capacity command module unless it is overtaken by the development of a small reuseable shuttle of the X-20 Dyna Soar class. In this event it is expected that the 4/2/4 Soyuz and the 4/3/3 Soyuz would be phased out while maintaining other Soyuz variants for longer non-Salyut related missions and future manned lunar explorations [7].

An analysis of the flights flown by the 12 Soyuz variants (Figs 1-2) yields an interesting progression of the changes encountered in the Soyuz spacecraft. From Fig. 1 the steady climb from the original 2/1/1 Soyuz in 1966 to the familiar 4/2/4 Soyuz in 1978 is readily apparent. The large numbers and varieties of Soyuz spacecraft launched between 1967 and 1969 indicate a massive development programme beyond that which is evident only by the flights of Soyuz 1 through Soyuz 8 during the same period. It should also be pointed out that during this evolution the overall capabilities were steadily cut. Although originally advertised as capable of reaching altitudes of 1300 km with flight times up to 30 days, the present Soyuz has minimal manoeuvring capabilities and a solo life-time of little more than two days.

Fig. 2 breaks down these yearly totals into the month of the year and the programme the mission was listed under. Again, with the exception of the research vehicles (1/1/1 and 1/2/3 Soyuz) and the Soyuz 10 and 11 missions (4/1/3), the usual Soviet practice is to test the spacecraft twice under the Cosmos label before committing it to a fully operational flight.

Progress Variant

January of 1978 witnessed the debut of a new Soyuz derivative - Progress 1. Although Progress 1, representing

Fig. 2. Soyuz Variants by Type and Programme

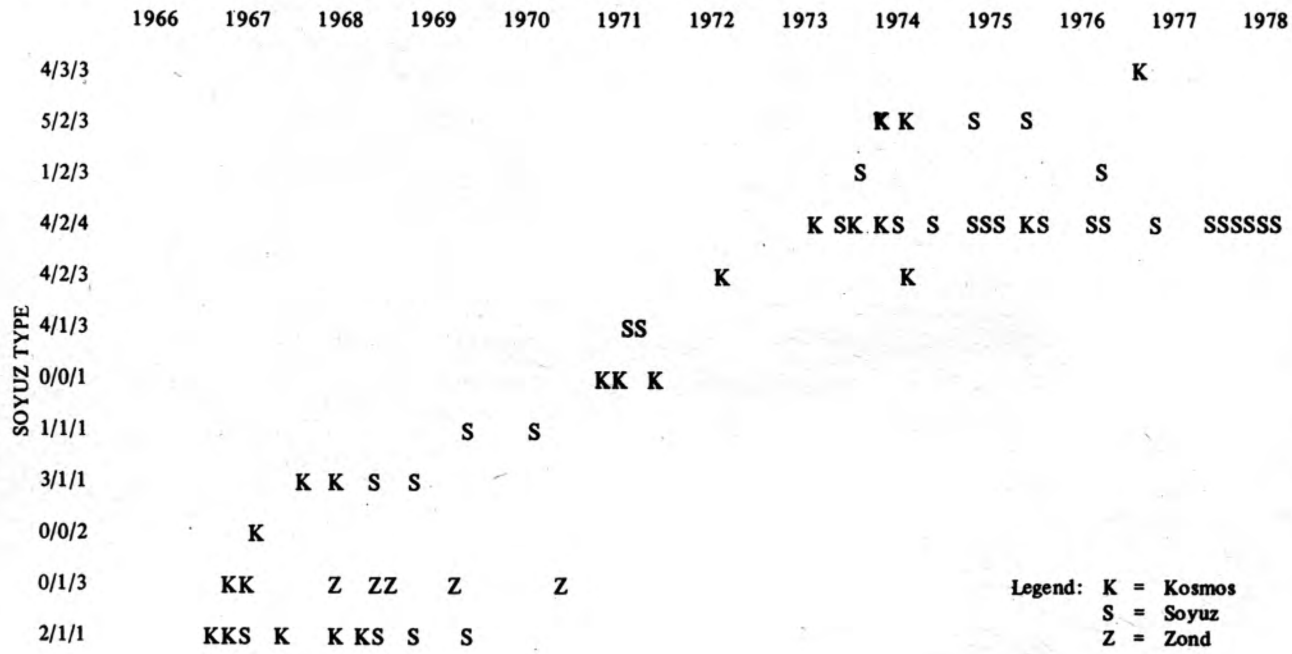


Fig. 3. Total Soyuz Variant Flights per Year

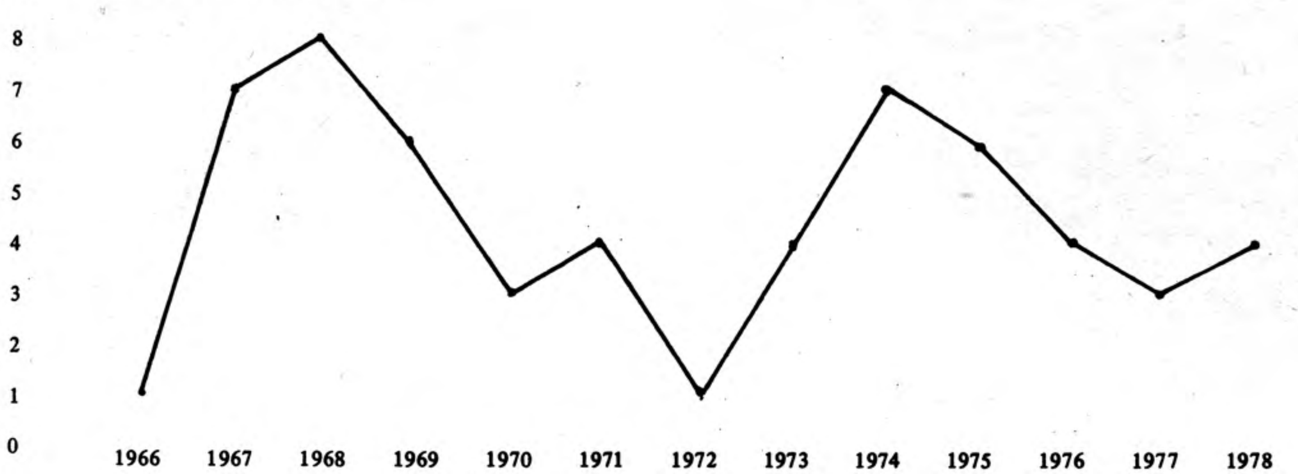
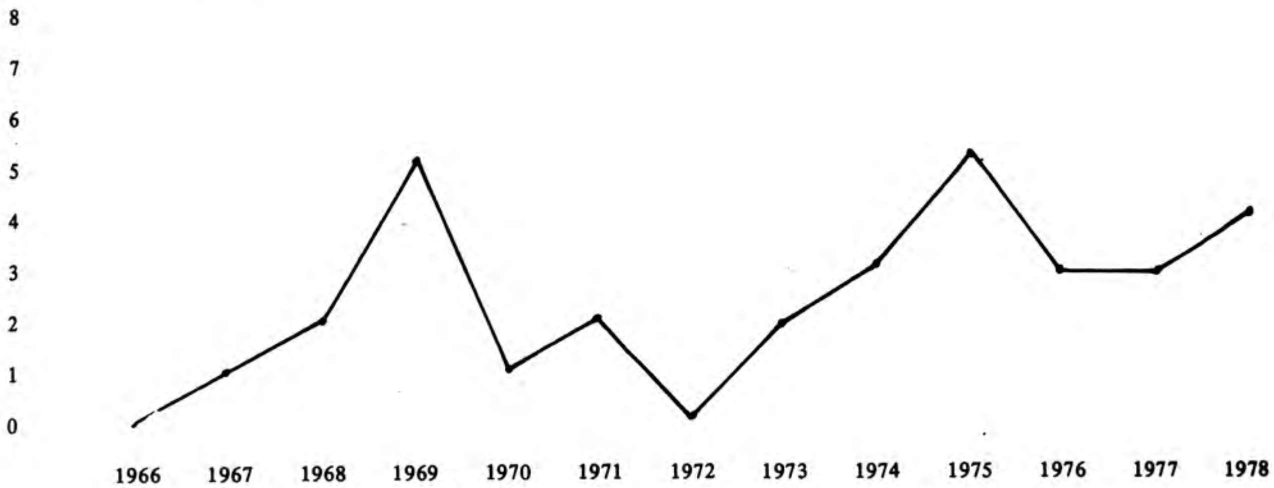


Fig. 4. Soyuz Programme Flights per Year



the first of a series of spacecraft designed to serve as automatic supply ferries to orbiting Salyut space stations, relies heavily on Soyuz hardware, the Progress spacecraft is not here considered to qualify as a variant of the manned Soyuz any more than the latest generation of recoverable surveillance satellites based on Soyuz. Recently released diagrams of Progress reveal extensively redesigned orbital and propulsion modules while the "command" module has been replaced entirely by a fuel storage compartment. In addition, whereas Progress is not intended to be manned, the Cosmos and Zond flights described here were directly related to man-rating equipment for Soyuz and manned lunar missions.

Soyuz Overview

Finally, in Fig. 3 and Fig. 4 an overview of the history of the Soyuz spacecraft and manned Soyuz programme can be obtained. Fig. 3 plots the number of all Soyuz variants (Soyuz, Cosmos, and Zond) on a yearly basis. Two distinctive peaks and three dips are clear. The first peak in 1968 represents the tremendous last ditch effort the Soviets were exerting to salvage the Soyuz programme after Soyuz 1 and the hope of still winning the manned circumlunar race. The maximum appearing in 1974 can be attributed to the renewed Soyuz/Salyut programme. Following the two-year hiatus caused by the fatal Soyuz 11 mission, Soviet programme managers were ready with improved and more versatile Salyut space stations. At the same time, a new Soviet emphasis in 1974 would sharply contrast with the much reduced United States space programme after the completion of the successful Apollo and Skylab programmes.

At the other end of the spectrum, the first sharp dip in the graph occurs during the year 1970 when it is assumed the final decision to terminate the manned lunar landing programme and proceed with Earth orbital stations was made. The even sharper minimum in 1972 is a direct result of the devastating effect which the deaths of the Soyuz 11 cosmonauts in 1971 had on the Soviet space programme.

One may assume that the final dip in 1977 is probably a year later than originally planned. The failure of Soyuz 25 to dock with Salyut 6 in 1977 cancelled at least two more manned and one unmanned missions scheduled for late that year. A dip in 1976 would correspond to the lag time required before the extensively redesigned third generation Salyut – Salyut 6 – was ready.

A comparison of Fig. 3 with Fig. 4, which lists only the Soyuz programme flights, yields yet another characteristic of the Soviet man-in-space programme. Again two dominant peaks appear, but this time they fall exactly one year behind the peaks of Table 8A. Hence, the increased activity in 1968 and 1974 foreshadowed the increase of manned flights in 1969 and 1975. However, as might be expected when the decision to cancel the manned lunar programme was made and when the Soyuz 11 accident occurred, all space activity (manned and unmanned) decreased immediately. If indeed the postulated flights of late 1977 had been flown following a successful Soyuz 25 mission, the third dip of both graphs would also coincide.

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2. For a selection of previous Soyuz variant systems, see:
   Soviet Space Programs, 1971-1975, U.S. Senate, Committee on Aeronautical and Space Sciences, 30 August 1976, pp. 493-498.
   Gatland, Kenneth, *Manned Spacecraft*, Macmillan Pub. Co., Inc., Second revision, pp. 236-237.
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   Wilding-White, T.M., *Jane's Pocket Book of Space Exploration*, Collier Books, 1977, p. 15.
3. "Red Spacecraft May be New Soyuz", Washington Post Dispatch in *Orlando Sentinel Star*, 22 Dec, 76, p. 6-A.
4. *Flug Revue*, Jan. 1977, pp. 17-19.
5. Woods, David R., "The Soyuz Propulsion System", *Spaceflight*, August, 1974, pp. 300-302.
6. There is some dispute over whether Zond 4-8 did indeed carry the toroidal fuel tank. Due to the sparcity of firm evidence to support either case and due to the ability to accomplish the missions without the added tanks, the author assumes here that the doughnut shaped fuel tank was not present. Likewise, while many assume that had Zond ever carried men only one cosmonaut would have flown, no separate command module designator is needed; e.g. Soyuz 1 and 3 only carried one cosmonaut in the three-seat cabin.
7. If the new three-man Soyuz is developed for use with Salyut space stations, one would expect the solar panels to be absent. Thus the variant would be a new 4/3/4 Soyuz.

SOVIET SPACEBORNE RADIOTELESCOPE PROJECT

By Boris Belitsky

Introduction

More details have emerged in Moscow concerning the Soviet spaceborne radiotelescope project, first reported to the 28th Congress of the International Astronautical Federation, held in Prague in September 1977. Various aspects of the work on this project have involved some of the Soviet Union's leading space scientists, including the director of the Institute of Space Research in Moscow, Dr. Roald Sagdeyev, his deputy Dr. Nikolai Kardashov, the astrophysicist Dr. Iosif Shklovsky, and the spacecraft designer Dr. Konstantin Feoktistov, who made a space flight in Voskhod 1 in October 1964.

The project seeks to utilise the gains in sensitivity and angular resolution that would follow from increasing the size of antenna arrays and spacing them further apart. The great promise of such advances for radio astronomy has already been discussed in *Spaceflight* [1].

The orbiting dish telescope envisaged in the project would be constructed with the aid of a reusable launch vehicle. The reflector would be built up by the step-by-step addition of standard antenna modules 100 to 300 metres in diameter and would have automatic surface control. Specifically, in the case of 200-metre hexagonal modules, each would be fitted with a four-metre flat reflecting cell. The tilt of each cell and each module would be regulated by commands from an unmanned controlling spacecraft positioned in the centre of the sphere. The complex would be most effective in the decimetre, centimetre, and millimetre ranges with array diameters of 1-10 kilometres. Space technology and the general "state of the art," it is felt, have developed to the point where the establishment of large complexes of this type should be feasible in the very near future.

Vastly Enhanced Potential

Neither of the two main characteristics of radiotelescopes – resolving power or sensitivity – can be enhanced much further on the ground. With ground-based radio interferometry now employing very long baselines close to the diameter of the Earth, further gains in resolving power can, in fact, be achieved only by spaceborne arrays. Similarly, further increases in the size of ground-based arrays – and, hence, sensitivity – are constrained by such factors as the effect of atmospheric inhomgeneities. Calculations carried out by the Soviet authors of the project show that at array diameters of 1-10 kilometres, wavelengths of 1 millimetre to 1 metre, and a maximum baseline of 10 astronomical units, both sensitivity and resolving power would be enhanced several millionfold. Still another advantage would be the exclusion of man-made radio interference, the level of which on our planet is now very high and keeps rising. This interference would be excluded by the positioning of the complex at a considerable distance from the Earth, by the screening effect of the reflector itself when facing away from the Earth, and by the erection of special screens in space. Such a complex would therefore make the whole of this radio spectrum available for radio astronomical studies, instead of the narrow bands reserved for such studies by international agreements today and accounting for no more than six per cent of the total radio spectrum.

All this being so, the authors of the project are convinced that the resulting enormous gains in radio astronomical potential would fully justify the very considerable outlays that the project would require, outlays analysed by them in a separate paper about to be published.

Astrophysical Applications

The authors of the project are especially interested in the potential of such a spaceborne complex for SETI, the search for extraterrestrial intelligence. Plans to this effect have already been reported in *Spaceflight* [2]. The search will be conducted to detect either radio signals of artificial origin or evidence of extraterrestrial engineering projects. Calculations show that a complex with a dish 1-10 kilometres in diameter should be able to detect a l-megawatt transmitter 10-100 light years away. In the event of the signals being beamed at our Solar System, the range would increase to 3-10 thousand light years, which is commensurate with the dimensions of our Galaxy.

Extraterrestrial engineering projects of the type known as the Dyson sphere could be detected, for example, by their screening effect on the background cosmic radiation, or alternatively by their own infrared radiation.

If the star encased by the Dyson sphere is assumed to be of solar magnitude, the authors estimate that the dish should be able to detect such artifacts at least as distant as the nearest galaxies.

Readers interested in the mathematics of these calculations are referred to a paper just published by the authors in Russian [3].

Similar calculations have been carried out to estimate the star- and planet-detection capability of such a spaceborne array. The radio emissions of stars of solar magnitude can be studied at distances of up to 10 thousand light years at a wavelength of 1 centimetre and at distances of up to 100 thousand light years at a wavelength of 1 millimetre. The significance of this becomes evident when one considers that up to now it has not been possible to register the radio emission of any normal star of the type of our Sun! For planets of the Jupiter type the respective distances for the same two wavelengths are 150 and 1,500 light years, while for planets of the Earth type they are 20 and 200 light years. It is noteworthy, in this context, that a sphere with a radius of 20 light years is estimated to contain 100 stars, many of which could have planetary systems.

Spaceborne Interferometer

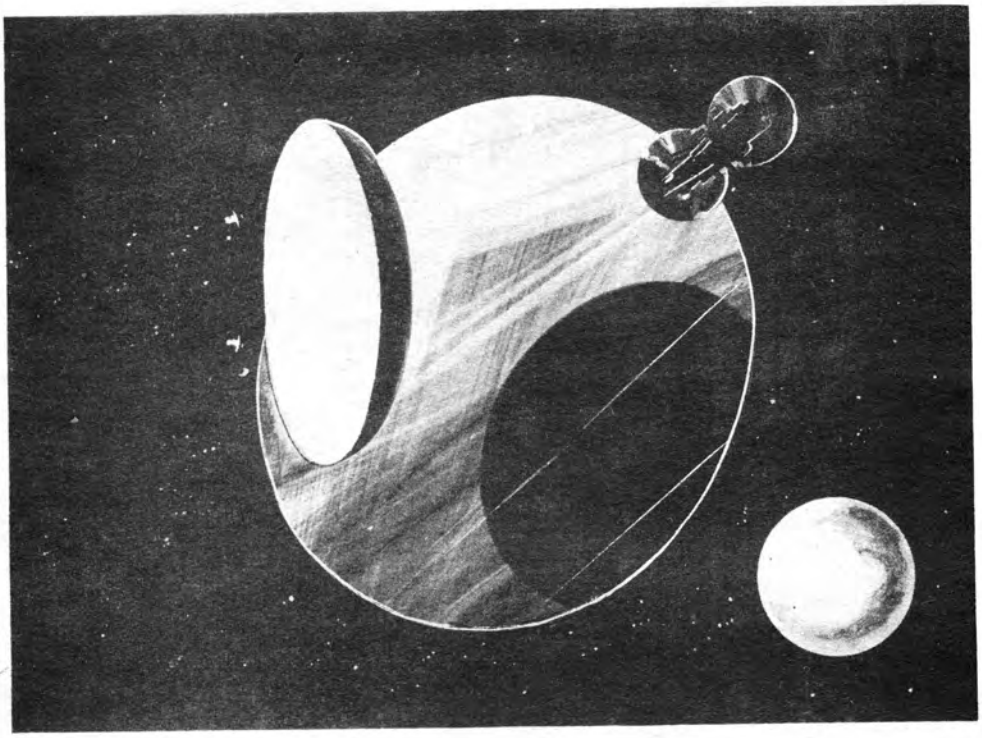
Interferometry by means of two spaceborne arrays would open up the entirely new possibility of obtaining 3D (holographic) images of distant sources and measuring the distances to them. Quite astonishingly, the maximum range of such measurements (equal to the Fresnel zone radius) turns out to be comparable to the radius of the curvature of the Universe. In other words, the entire Universe would be within the near field of a spaceborne interferometer! Similar experiments with a ground-based interferometer, even if it had the maximum possible 10,000-kilometre-long baseline, would have a range of only about 6.5 light years, which means they would reach only the four nearest stars.

The use of spaceborne arrays for interferometry thus holds out the promise of solving fundamental astrophysical problems that cannot be tackled by ground-based facilities.

Composition of Complex

The spaceborne radio telescope complex will consist of the main reflector, several autonomous spacecraft serving as feeds, and a controlling spacecraft to regulate the tilt of the modules and flat reflecting cells of the main reflector. The main reflector should be a dish of spherical shape to make possible the simultaneous study of several sources spaced far apart. This also reduces precision requirements to the attitude of the main reflector in space, since pointing accuracy would be achieved by the movement of the feed spacecraft. Their movement and the shape of the surface of the main reflector would be controlled from the controlling

SPACE SETI SYSTEM. This drawing illustrates a spherical space SETI system located at Lunar Libration Point L4 and two feeds, showing relay satellite and radio frequency interference shield. It was prepared from a study carried out by the NASA Ames Research Center, Moffett Field, California. The Soviet design is somewhat different but obeys similar principles. We hope to publish a drawing of the Soviet proposal in a future issue. Ed.



spacecraft, positioned in the centre of the sphere. The four-metre size of the flat hexagonal reflecting cells has been chosen with regard to convenience of transportation. The entire array can be enlarged indefinitely, but can be used effectively from an early stage of assembly.

I understand that Soviet scientists would welcome international co-operation on a project of this magnitude, since this would naturally speed its realisation.

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ELECTRICITY-SAVING INVENTION

United States industry has been invited to bid on a cost-sharing contract to commercialise an electricity-saving device recently invented by Frank Nola, an engineer at NASA's Marshall Space Flight Center in Huntsville, Alabama. The inexpensive, yet revolutionary device – known as a Power Factor Controller – has the ability to markedly reduce the power consumed by the billions of electric motors.

The controller works by continuously determining the precise amount of electricity needed by a motor, to which it is attached, to perform its work efficiently. It does this by sensing shifts in the relationship between voltage and current as the motor's workload changes. When it senses a light load, it cuts back the voltage level to the minimum required. Current flow drops as well, markedly reducing the power normally wasted through heat loss.

Tests already conducted on over 30 motors indicate the savings will range up to 60 per cent, depending on the workload applied.

The request for proposals, issued by the Marshall Center, specifies that the contractor selected "shall have the capability of manufacturing 30,000 units per month, and should provide as a part of this effort the estimated production costs based on production rates of 10,000, 20,000 and 30,000 units per month."

This type of cost-sharing contract is one method used by the Marshall Center Technology Utilization Office in making new technology available to the public, as required by the Space Act of 1958, and to demonstrate the utility and reliability of the technology.

Frank Nola of the Marshall Space Flight Center with a 'breadboard' model of his Power Factor Controller.

National Aeronautics and Space Administration

APPOINTMENT WITH JUPITER

VOYAGER 1 AT CLOSE ENCOUNTER

Introduction

Photographs of exceptional quality are anticipated from Voyager 1 as it makes its encounter with the giant planet Jupiter. The spacecraft, passing the planet at a distance of some 177,000 kilometres on 5 March, also provides excellent observation opportunities for Jupiter's Galilean moons.

The sister spacecraft Voyager 2 is due to make its close encounter on 9 July.

Mission Objectives

Objectives of the double mission are to increase knowledge of the origin and properties of Jupiter and Saturn, the two largest planets of the Solar System, and to gain additional information on interplanetary space in the outer Solar System. Emphasis is placed on obtaining data of the two planets, their satellites, and the rings of Saturn (*Spaceflight*, November 1977, pp. 392-393).

On-board computers will sequence operations to differing data acquisition requirements at Jupiter and Saturn. Data return should be easily achieved to at least 20 AU (3,000 million kilometres), reached eight years after launch.

Power for operation of the fully attitude-stabilised spacecraft is provided by radioisotope thermoelectric generators. After jettisoning the propulsion module that supplied the final velocity increment for the Jupiter trajectory, each spacecraft has a mass of about 825 kg, including 115 kg of science payload.

One of the most significant experiments being performed by both spacecraft concerns magnetic field measurements.

The magnetic field of a planet is an externally measurable indication of conditions deep within its interior. Four magnetometers aboard each Voyager will gather data on the planetary magnetic fields at Jupiter, Saturn, and possibly Uranus; the satellites of these planets; solar wind and satellite interactions with these planetary fields; and the interplanetary magnetic field.

If flight controllers are still in touch with the spacecraft when they pass beyond the orbit of Pluto and out of our Solar System, the instruments may beam back news of the interstellar medium as well.

Voyager's fields and particles investigations, of which the magnetic fields experiments is one, are complementary, having overlapping areas of study but each with its own unique methods of observing and reporting on the same phenomena.

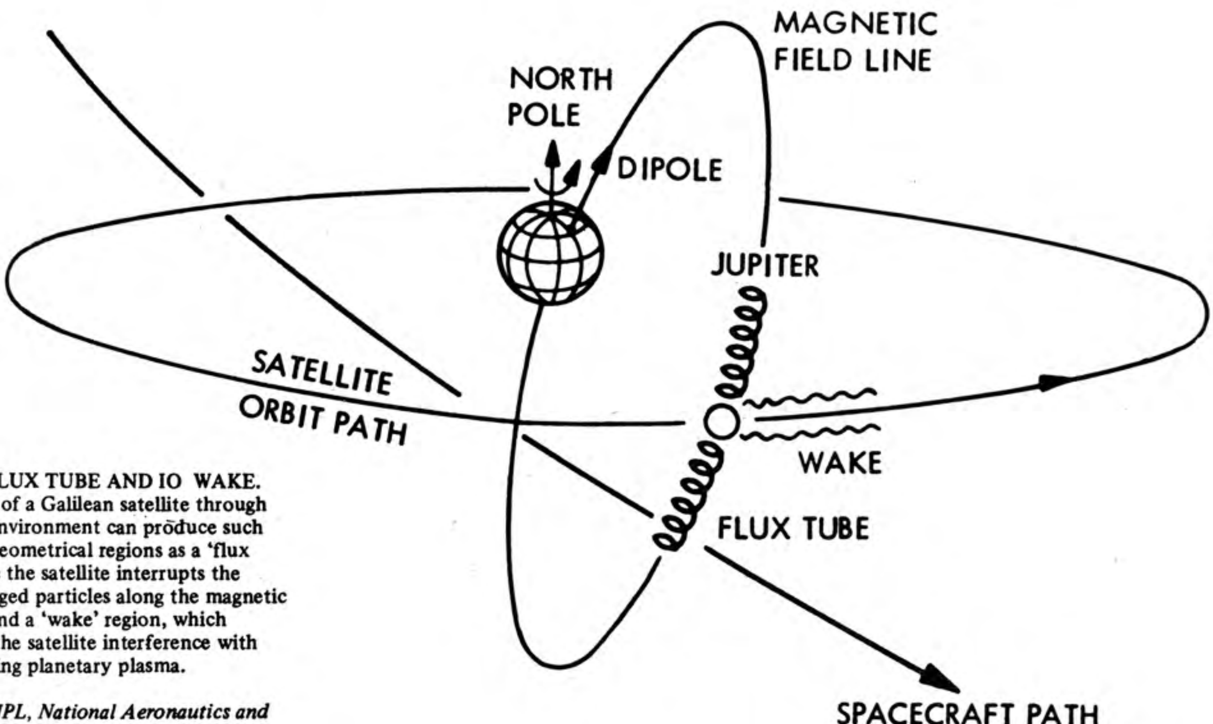
Solar Wind and Magnetospheres

The magnetometers will reveal a great deal about the interplanetary medium – the thinly scattered ionized and magnetized gas within the spaces of our Solar System – which forms the solar wind.

Our Sun is constantly emitting electrically-charged particles, mostly protons and electrons, from the ionization of hydrogen. This gas is in the fourth state of matter called a very high "plasma" (the other three states being solid, liquid and gas). It travels at speeds varying from 300 to 1,100 kilometres (185 to 685 miles) per second. Although of extremely low density (less than 100 particles per cubic centimetre, the plasma permeates all of interplanetary space. Because of its ionized state, it is an electrically-conducting medium in interplanetary space.

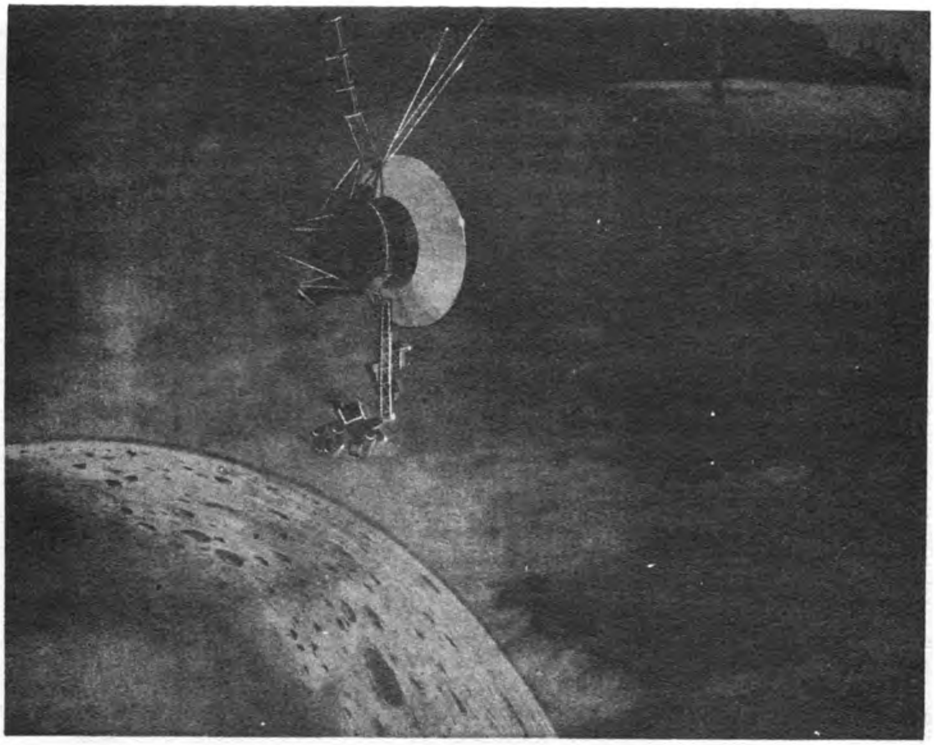
The solar wind is deflected by planetary magnetic fields and streams around the obstacle, confining the planet's magnetic field to a limited region of space called the magnetosphere. At Earth, the magnetosphere is a long, narrow tail on the far side of the planet (away from the Sun). The ion tails of comets (but not the dust tails) also stream in the direction of the solar wind flow.

Well past the orbit of Uranus (at 20 AU), Voyager will be alert to detect the outer edge of the solar wind, although this



JUPITER FLUX TUBE AND IO WAKE.
The motion of a Galilean satellite through the Jovian environment can produce such interesting geometrical regions as a 'flux tube', where the satellite interrupts the flow of charged particles along the magnetic field lines, and a 'wake' region, which arises from the satellite interference with the co-rotating planetary plasma.

JPL, National Aeronautics and Space Administration



THE 'FLUX TUBE' is a region of magnetic and plasma interaction between the big satellite Io and Jupiter. This painting shows the flux tube at Io (upper right) and contacting the upper atmosphere of Jupiter (lower left). Voyager 1 was carefully aimed to pass through this unusual region shortly after closest approach to Jupiter on 5 March.

JPL, National Aeronautics and Space Administration

may be as far distant as 50 AU (7,500 million kilometres or 4,750 million miles), well beyond the nominal limits of the mission.

The three-dimensional shape of Jupiter's magnetosphere is not well understood. The timing of the Voyager arrivals at Jupiter, four months apart, will allow concurrent measurements of the interplanetary medium near Jupiter and the Jovian magnetosphere itself. Thus, changes in characteristics of the magnetosphere can be identified as true spatial variations or as temporal ones induced by changes in the interplanetary medium.

Jupiter's rapid rotation rate (1 Jovian day is about 10 Earth hours) may be a cause of the strongly distorted outer magnetosphere. At large distances from the planet, the magnetic field lines appear to form a spiral structure, which might be explained by outward plasma flow.

The interaction between a satellite and the Jovian magnetosphere depends on the properties of the satellite and its ionosphere, on the characteristics of the field and particle environment, and on the properties of the Jovian ionosphere.

The Jovian magnetosphere rotates with the planet, extending as far as the orbit of Callisto, the fourth Galilean satellite of Jupiter.

Io Interaction

A strong factor in choosing the spacecraft flight paths was the desire to observe a special region of interaction between Jupiter and its satellite Io, known as the flux tube. The flux tube is defined by the magnetic lines of force of Jupiter which pass through Io, and is roughly a banana shape.

Voyager 1 is targeted to pass through the flux tube at a distance of 25,000 kilometres (15,500 miles) from Io, and should return a definitive observation of the interaction. The spacecraft will spend a maximum of 4-1/2 minutes in the flux tube.

Decametric radio wave noise bursts (4 to 40 kHz) from Jupiter are a puzzling phenomenon on which is probably connected with plasma instabilities within the Jovian ionosphere. The satellite Io appears to exert some influence on these radio emissions through its magnetic flux tube, which intersects both the plasma around Io and the Jovian atmosphere.

Io is thought to have no internal magnetic field, although its rocky surface, and that of Europa, should have some magnetizable material. Io is known to have an atmosphere and to be a source of sodium.

Saturn and Titan

Saturn may also have a magnetic field and magnetosphere similar to Jupiter's, but its magnetic field is expected to be somewhat weaker. There is no large satellite like Io close to Saturn. The major Saturnian satellite to be studied by Voyager, Titan, is more than one million kilometres (620,000 miles) from the planet and may or may not be inside the planet's magnetosphere.

Titan is larger and more massive than Earth's Moon and has a gravitationally-bound atmosphere. Study of Titan will be of special significance, and Voyager 2 may have an opportunity to measure Titan's "wake" as the satellite moves through the solar wind or the Saturnian magnetosphere.

Uranus

The option to divert to Uranus allows for a decision to be made on the Voyager 2 trajectory before Saturn encounter. Voyager 2 can repeat Voyager 1's mission or it can take an alternative course that leads to an encounter with Uranus in January 1986.

JPL points out that the option will be exercised only if Voyager 1 accomplishes all its objectives at Saturn, and if Voyager 2 is healthy enough and its expendables can be budgeted to undertake the additional four-year flight to Uranus.

If the Uranus flyby option is realised, a "pole-on" probe of the Uranian magnetosphere may be possible, since the axis of Uranus points almost toward the Sun. The magnetosphere appears to include the orbit of the satellite Oberon.

Acknowledgement

The editor wishes to thank Mr. Bill Becker, Public Affairs Office, Jet Propulsion Laboratory, Pasadena, for information contained in this article.

MKF-6 MULTI-SPECTRAL CAMERA IN SPACE

By Wilhelm Hempel*

Introduction

In September 1976 Soviet cosmonauts Valeri Bykovsky and Vladimir Aksyonov orbited the Earth 127 times in their Soyuz 22 spacecraft. Their equipment included a multi-spectral camera designed and made by experts of the German Democratic Republic and the Soviet Union in the nationally-owned Carl Zeiss factory at Jena, GDR.

The camera, which weighed 175 kg, had already been tested successfully in a previous trial. It produced a series of 2,400 pictures each consisting of six frames, in different wave bands of the visible spectrum and the infrared. The camera has a surprisingly precise mechanism, so the single black-and-white pictures in a set show exactly the same section of the surface of the Earth but with different exposures. This is a result of the different colour and radiation characteristics of the objects photographed by the camera. There is a four-channel MSP-4 multi-spectral projector which can be used by the expert analysing the pictures to superimpose four of them from every set; by adding colour filters he produces not only the "natural" picture but any contrast in colour he chooses.

The camera can bring out differences hidden to the viewer's eye in normal photographs or stereoscopic pictures, e.g. differences between healthy and diseased vegetation, clean and polluted lakes and rivers and dry and moist soils. This means that pictures taken by the multi-spectral camera have very many uses.

First MFK-6 Camera

The first MFK-6 camera onboard Soyuz 22 obtained pictures (55 x 80 km) of an area of about 19,000 square kilometres. Theoretically, six sets of pictures taken by the "six-lens" camera would be enough to show the whole territory of the GDR. The resolving power of this camera is two or three times greater than that of the most up-to-date aerial cameras. In fine weather one can recognise even small weekend houses on the pictures – taken from a distance of 250 km!

The difficulty, however, was that the transport capacity of the descent module of Soyuz 22 was too small to accommodate more than two of the very large sets of cassettes back to Earth. So it was decided to instal another camera in the Soyuz 6 orbital station in order to use this valuable apparatus for a long time and as effectively as possible. This made it necessary to perform a number of technical changes. The result was the MKF-6M camera, "M" standing for "modified."

MKF-6M

The first camera for cosmonauts Bykovsky and Aksyonov was to be in operation between 10 and 15 days. The MKF-6M, however, will work for two years. That is why the designers of the new version doubled the vital mechanical and electronic systems. By making the parts more robust the camera will not only cope with the normal loads during take-off – due to vibration and acceleration – but also with the additional loads resulting from the docking manoeuvres in the shuttle operation between the Earth and the orbital station.

The experts made special efforts to make the handling of the camera easier. Yuri Romanenko and Georgi Grechko, Vladimir Kovalyonok and Alexander Ivanchenko, the first two skeleton crews of Salyut 6 and their colleagues from the socialist countries, were able to do all the necessary operations with one hand using the other, if necessary, to

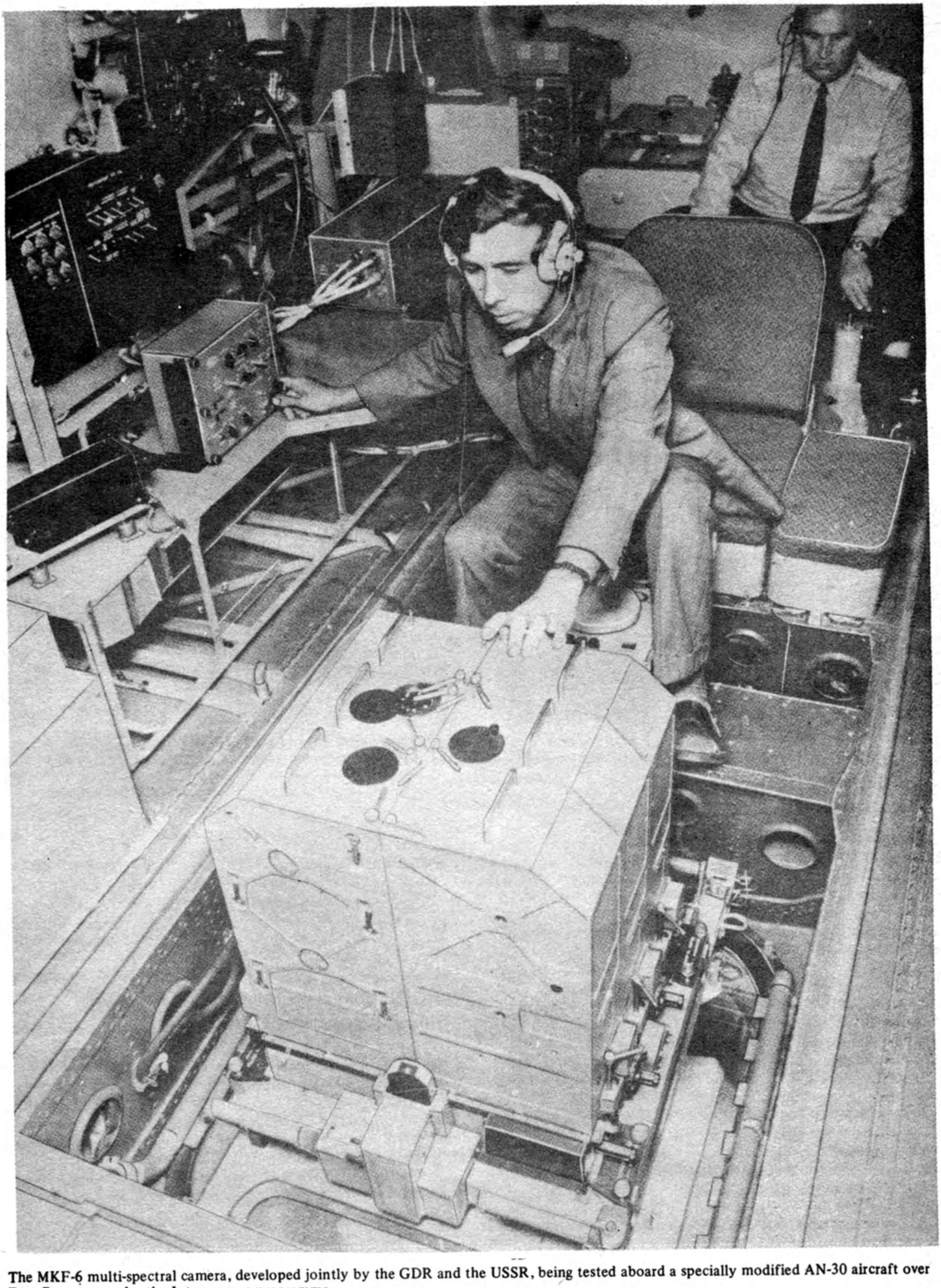
SPACE PHOTOGRAPHY. Valery Bykovsky (right) and Sigmund Jähn, crew of Soyuz 31 during pre-flight rehearsals in an engineering mock-up of Salyut 6. Their research programme aboard the space station included taking photos of the Earth's surface including the territory of the German Democratic Republic, using the MKF-6M multispectral camera made by Carl Zeiss Jena. Here, they are loading one of the 13 kg (28.6 lb) cassettes into the camera.

Novosti Press Agency

Space duration record holders Vladimir Kovalyonok and Alexander Ivanchenkov who carried out an extensive programme of photography from Salyut 6. They are seen at work in space during the visit of Bykovsky and Jähn.

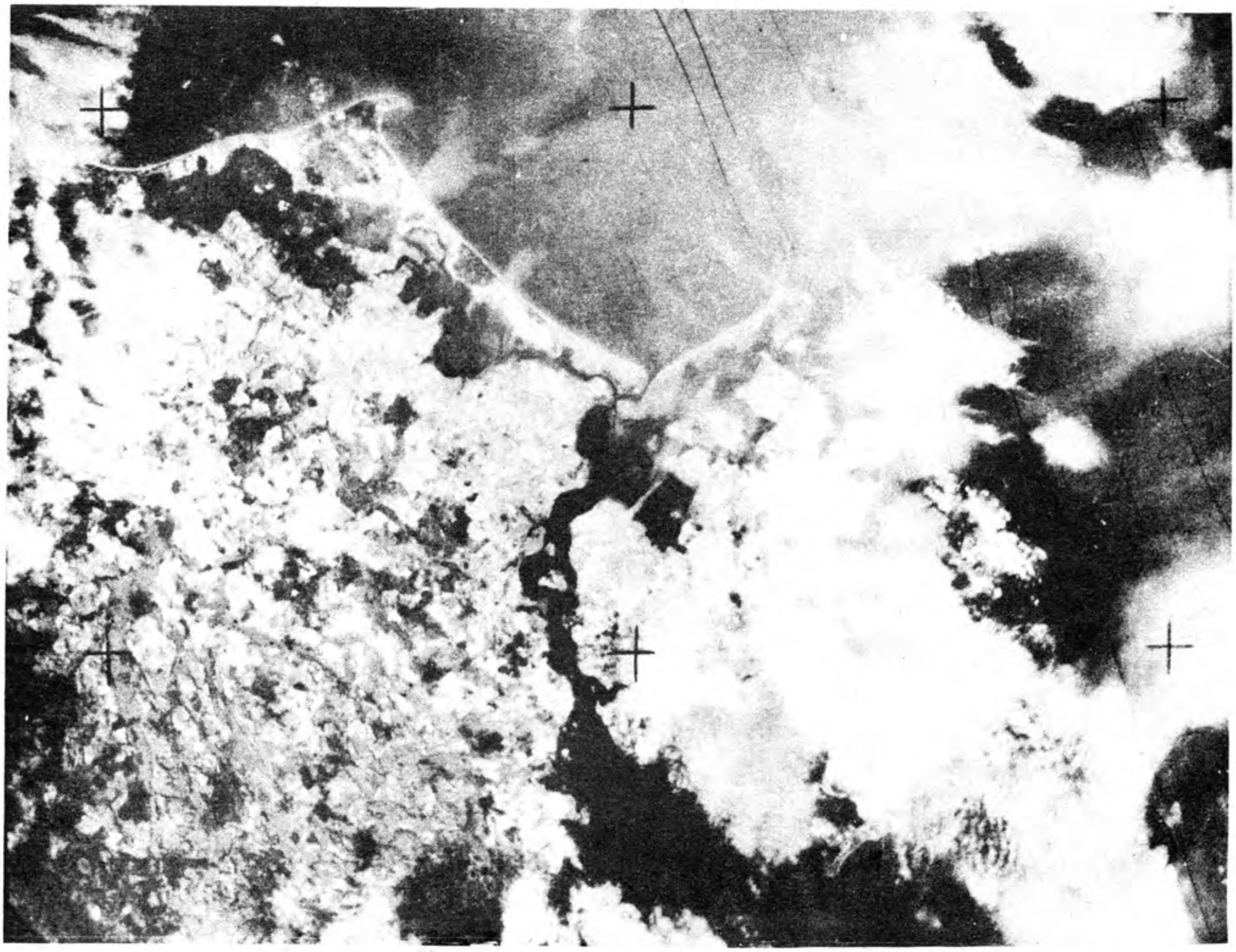
Panorama DDR/Zentralbild

* *Presidium Member, GDR Astronautical Society.*



The MKF-6 multi-spectral camera, developed jointly by the GDR and the USSR, being tested aboard a specially modified AN-30 aircraft over East Germany under the Intercosmos programme.

Panorama DDR/Zentralbild



Photograph taken by the original unmodified MKF-6 multispectral camera from Soyuz 22 in 1976 of the Northern part of the German Democratic Republic. Clearly seen is the coast of the GDR including the islands of Rugen, Hiddersee and Darss. The picture was taken from an altitude of 260 km (161 miles).

Panorama DDR/Zentralbild

hold on to something in the roomy station where they worked under conditions of weightlessness. The sprocket devices were also improved making it easier to change the cassettes.

When the camera is working GDR specialists are available in the control centre near Moscow in order to render assistance in case of difficulty. This made it necessary to give the control centre increased telemetric information about the functioning of the camera. This is done by two additional devices which showed if the camera was switched on and the film advanced. They record the altitude automatically. The whole apparatus is arranged like a flight-path plotter. It cannot be manipulated by the cosmonauts.

The image sharpness has also been improved with the new version of the multi-spectral camera. Resulting from the higher flight altitude of Salyut 6 a single picture now shows an area of 155 x 225 km, i.e. about 35,000 square kilometres. This is 84% greater than was achieved with the camera aboard Soyuz 22.

The new version of the multi-spectral camera satisfies all the wishes of its numerous "customers." They include the Zeiss factory in Jena; the Institute for Electronics and the Central Institute for Terrestrial Physics (both affiliated to the GDR Academy of Sciences); the Administration for Surveying and Maps and Charts; the Institutes of Geology and Forestry and the Ministry for Water Supply and Environment.*

A TICKET TO SPACE

By Curtis Peebles

In our issue of January 1978 we looked into the claims of the West German company of OTRAG to go into space by low technology. We have since heard of another "private venture" space project being pursued by the veteran rocket pioneer Robert Truax in the United States.

The Volks-rocket and its designer, Robert Truax. The vehicle makes a maximum use of proven components to decrease cost and improve reliability.

Truax Engineering, Incorporated

Introduction

Since the space age began, people have watched rockets climb into the blue Florida sky and beyond; thinking to themselves "if only....." One need not have the advanced degrees, perfect health or the thousands of hours of flight time this frontier has demanded to be attracted towards it. Yet, because so few people meet these requirements, spaceward ambitions must remain a dream. If Robert Truax and a small group of associates are successful, that no longer need be true.

The X-3 Volks-Rocket

Robert Truax brings some forty years of experience to his private manned space flight programme. He is the former director of the Advanced Development Division of Aerojet General Corporation. Before and during World War II, he worked with the U.S. Navy rocket programme, was part of the Atlas and Samos projects and was decorated for his work on the Polaris missile concept. He was, also, one of the organisers of the "Big Dumb Booster" idea [1].

After retiring from Aerojet General, he built steam rockets for drag racing. Then, in the early 1970's, he began to study the possibilities of a small manned sub-orbital reuseable booster constructed of surplus rocket components. The "back of the envelope" calculations were interesting enough for him to begin buying used parts.

In the meantime, motorcycle stunt man, Evel Knievel had used one of Truax's steam rockets in an attempt to jump the Snake River Canyon (Truax designed and built the Skycycle X-2). Knievel came to Truax afterwards and asked if there was anything that could top it. Truax responded "for a million dollars, I could make you the first private astronaut." Knievel was interested enough to pay for a feasibility study. It confirmed Truax's initial estimates.

The X-3 Volks-rocket, as Truax likes to call the vehicle, stands 24 ft (7.32 metres) tall and is 25 in (63.5 cm) in diameter. Empty weight is 1.100 lb (500 kg); fuelled it weighs 3,100 lb (1,409 kg). The propellants (liquid oxygen and kerosene) are pressure fed to four Atlas vernier engines (Rocketdyne LR 101's) giving a total thrust of 4,000 lb (1,818 kg). A propellant utilization system insures simultaneous depletion of both propellants. Guidance is provided by HIG-4 floated gyros. Components would be sealed against salt water contamination; exposed portions would be washed off with a fresh water hose.

The vehicle is designed to reach an altitude in excess of 50 miles (80.5 km) qualifying the passenger as an astronaut.

When Truax began development, the major problem was with the engines. The Atlas vernier engine's fuel system was designed to feed a single engine. Truax had to design a new manifold and gimbal system. Up to late 1978, six static tests of the new fuel system have been made. For these early tests, only one engine was installed. Also tested were the steering servos which gimbal the engine. Engine operation, at reduced pressure, was checked. This allowed the removal of one of the two pressurised helium spheres in the original design. All tests were successful.

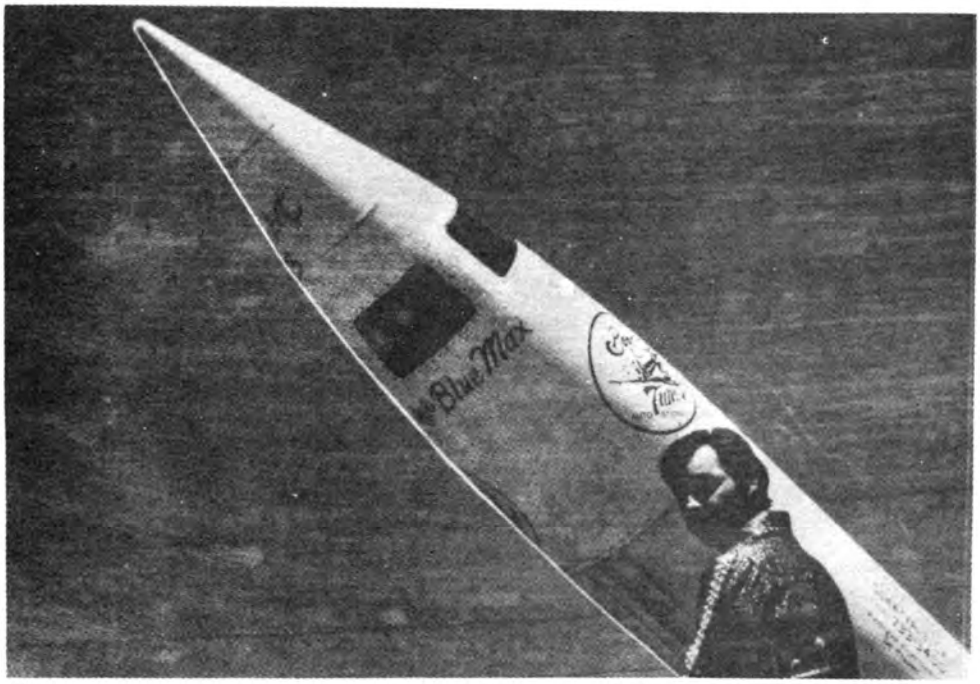
In addition, there have been two tests of the life support system. One was a test of the passenger capsule's pressure integrity. Second, was a 30 minute manned, sealed test of the capsule. This checked out the life support system's function for the time necessary to count down, launch and recover. Smaller component tests, such as on regulators, were also run [2].

Funding

All space programmes have funding troubles, even private ones. Because of this, development has been slow and the launch date is uncertain. It could be as soon as 18 months (immediate full funding) to five years (Truax's own resources). Total development costs are estimated to be between one-half and one million dollars.

Like other commercial endeavours "Project Private Enterprise" has sought sponsors. Truax has, so far, recruited a travel agency, a solar energy company, a San Jose water bed firm, a Greek restaurant and a car stereo store [3]. TV networks have also expressed interest.

In the future, the hard mock-up will undergo static tests. Manned drop tests will help select the optimum splashdown velocity. The data will be used to size the main parachute. After these are completed, it will be dropped unmanned from a helicopter at an altitude of 20,000 to 25,000 ft (6,096 to 7,620 metres) to test the recovery systems and fleet (a large boat, divers, 2 helicopters and an aircraft). A secondary goal is structural checks. Ground



Candidate astronaut, Martin Yahn and the capsule in which he will ride. The passenger capsule is divided into two parts' a short cylinder in which the astronaut sits and the nose cone which fits over it.

Truax Engineering, Incorporated

tests will be used to insure maximum reliability. Truax estimates a 90 to 98% chance of survival for the first flight.

Flight Tests

Two flight rated Volks-rockets will be built at a cost of $300,000. They will be used first in an unmanned flight. After a completely successful flight has been obtained, a manned mission will be attempted. The astronaut for this flight will be Martin Yahn, 31, of San Jose. He was selected from 50 applicants and has assisted Truax during development. The idea is that the booster will be set up near the Pacific Ocean and then fuelled. The astronaut will be placed in the capsule which will be lifted by crane and attached to the rocket. The booster will be counted down and fired. TV and two-way communication links will assure contact between the launch site and the astronaut.

Burn-out will occur at 100,000 ft (30,480 metres). Maximum acceleration will be 3 g's. The momentum will carry the rocket, now slowly tumbling, to peak at an altitude in excess of 50 miles (80.5 km). Through the three windows, the length of California will be visible as well as the curvature of the Earth and the deep blue-black of space. Its momentum spent, the Volks-rocket will start down. At 150,000 ft (45,720 metres) a small drogue parachute will deploy to stabilise the Volks-rocket in the proper nose-up configuration and slow it to 400 mph (644 kph) at 20,000 ft (6,096 metres) when main chute deployment occurs. At this time, a port opens to supply fresh air and the booster is lowered to splash-down. Total flight time, lift off to splash-down, is 10 minutes. If successful, Martin Yahn will become the world's first private astronaut [4].

The flight will be tracked by radar and its course monitored by a range safety officer. If the Volks-rocket goes off course, the range safety officer will shut down the engines and tell the astronaut to throw the on-board cut-off switch. The capsule locking bolts will release and an escape rocket will fire, accelerating it clear of the booster; then the normal parachute sequence takes place. Above approximately 1,000 ft (305 metres), the escape rocket will not be necessary; only the separation sequence. If the drogue chute fails, the vehicle will stabilise in a slow flat spin, decelerating it to normal main chute deployment speed. As a last ditch, the astronaut, who will wear a chest pack parachute, would jettison the nose cone and bail out.

Once the Volks-rocket has proven reliable, regular passenger flights could begin. Truax estimates that ticket costs would be $10,000 covering launch costs and profit.

Because of the size of the capsule, persons over six feet (1.83 metres) would be cramped. Vehicle performance limits passenger weight to 200 lb (90.7 kg). Anybody over this would be put on a diet before launch. As Odyssey Travel Service, one of the sponsors, puts it, the occupant would indeed have "a unique experience in travel."

Conclusions

Truax's project, beyond the obvious implications of commercial manned space flight (however brief), is different in that it is the dream of a single individual. The early history of rocketry is one of individuals working virtually unaided. With the coming of World War II, these individuals would vanish to be replaced with a team concept; thousands of engineers working for hundreds of contractors, supported by the resources of a nation. It is, therefore, ironic that the pattern of a whole new industry is taking shape in a Saratoga, California garage.

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2. Phone call to Robert Truax, 11 October 1978.
3. *Space Age Review*, March/April 1978.
4. *Space World*, August/September 1978.

NEXT MONTH.

Features scheduled to appear in our April issue include: 'The Salyut 6 Space Station' by Nigel Kidger; 'International Hall of Fame'; 'The Cosmic Blackbody Radiation: A Potential Guide to Interstellar Signal Beacons?' by Robert Sheaffer; 'Second High Energy Astronomy Observatory,' and 'Astronomical Notebook' by Prof. J. S. Griffith.

THE MANY SHADES OF THE 10TH PLANET

By Anthony T. Lawton

"What is your substance, whereof are you made,
That millions of strange shadows on you tend?
Since every one hath, every one, one shade,
And you, but one, can every shadow lend!

William Shakespeare - Sonnet 53

Introduction

The above stanza could well have been written for the "tenth planet," for this elusive object - if it exists - has assumed "millions of strange shadows." New data concerning Pluto has revived interests in the possibility of there being one more planet. This paper reviews the current situation and outlines methods by which the shadows may possibly be converted to substance.

Pluto - The Shrinking Planet!

When Percival Lowell had determined the orbital elements of Planet X (his name for a hypothetical trans-Neptunian planet) he assigned to it an equivalent diameter of 25,500 km (16,000 miles). He based this figure on the assumption that planet X would have a similar albedo to Neptune, and also have a similar density and composition.

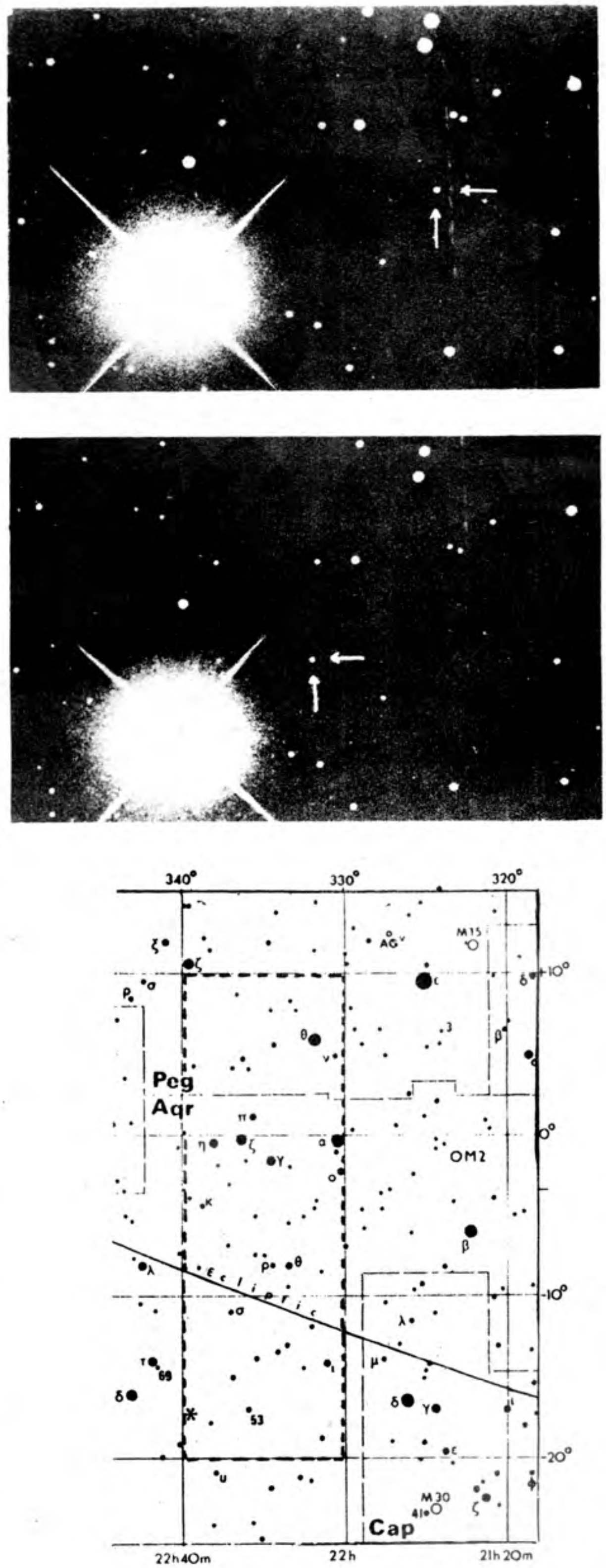
When discovered, the planet proved to be much fainter than forecast, and initial measurements made by Kuiper in 1949 showed that the diameter was about 10,000 km (6,300 miles). But Pluto (the name assigned to the planet) appeared to fit the predictions made both by Lowell and Pickering, bearing in mind the crude data on which they worked. Then in 1950 Humason and Kuiper using the 5 metre (200 in) Palomar mirror were able to reduce the errors on Kuiper's work of the previous year. In doing so, they also drastically lowered the diameter to 5,800 km (3,600 miles), Pluto was now smaller than Mars!

In 1977 accurate measurements of surface constituents by Cruikshank allowed the albedo, and hence the surface area to be estimated [1]. This placed an upper limit on the planet's diameter of about 2,700 km (1,700 miles). In 1978 Christy's discovery of a companion [2, 3] officially designated 1978 P_1 (but called Charon by its discoverer), placed an upper limit of 1.56×10^{22} kg on Pluto's mass. This is a mere $^1/_{383}$ of that of Earth which weighs in at 5.97×10^{24} kg. Thus, with a density of 1.0 or slightly less, Pluto is nothing more than a very large snowball! The final state of wretchedness in this celestial 'Rake's Progress' has now been reached, for Dr. Brian Marsden of the Smithsonian Astronomical Observatory has suggested that Pluto is really a large planetoid. He underwrites his case by pointing out the strong similarities in orbital behaviour between Pluto and Chiron, the slow moving planetoid discovered by Kowal [4, 5].

As the data has improved, so the characteristics of Pluto have become more like those of a minor rather than a major body, and these parameter changes are highlighted in Table 1. The mass is so low that it could not possibly have caused the perturbations of Uranus and Neptune which formed the calculation basis of Lowell and Pickering's work.

Although long since dead, their notes carry an undertone of foreboding for Lowell wrote:

> "Analytics thought to promise the precision of a rifle and finds that it must rely on the promiscuity of a shotgun after all".



Right: Fig. 1. Pluto (arrowed) by moving perceptively during the time interval between the two photographs, revealed itself as the planet predicted by Lowell. The top photograph was taken by Tombaugh at Flagstaff on 2 March 1930 – the lower one on 5 March. The bright over-exposed star is Delta Geminorum of magnitude +3. The bottom illustration is a likely search area for Planet 'X' should the hypothesis developed in this article be reinforced by further orbital perturbation data.

Photos: Lowell Observatory

TABLE 1. The Changing Diameter of Pluto

Research	Date	Diameter Km	Diameter Miles	Mass Earth = 1
Lowell Pickering	1890 to 1914	25,000	15,000	6.0
Kuiper	1949	10,000	6,300	0.7
Kuiper Humason	1950	5,800	3,600	0.1
Cruickshank Christy	1977 1978	2,500 to 2,700	1,560 to 1,700	0.002 to 0.0027

Unfortunately he died before Pluto was found, but Pickering lived to see the discovery, and afterwards he wrote:

> "When I first recognised its importance from its comets, I mentally reserved for it the name Pluto, as the son of Saturn and the brother of Jupiter, and Neptune; but unfortunately that small object *now* known as Pluto came round and perturbed Neptune some ten years before the leisurely P arrived and perturbed Uranus and so received the name. Pluto should be renamed Loki, the god of thieves! A suitable name for P will indeed be difficult to find when that planet is discovered".

Poor Pluto! Downgraded to a minor planet, and labelled as a thief of titles! I feel sympathetic toward Dr. David Hughes's suggestion of naming Pluto's companion 'Persephone' instead of Charon [6]. Persephone was the fair goddess who was queen consort of the underworld. In his present abject status Pluto could do with feminine companionship!

For a less romantic and much more practical reason, Persephone is to be preferred on the grounds of avoiding phonetic confusion between Charon and Chiron. It would also leave the name Charon for the tenth planet - should it ever be discovered. Loki is of Norse origin and would definitely be an interloper in this preserve of Romano-Hellenistic mythology.

A False Dawn

In 1972 Brady and Carpenter gave details of the ephemerides for a hypothetical 10th planet which had been obtained by reduction of the residuals of the orbital motion of Halley's Comet [7, 8, 9]. They were attempting to accurately forecast the perihelion date of the comet which is due to return in 1986. The mean period is often quoted as approximately 76 years, but some 15 past observations have shown considerable departures from the dates expected of a pure Keplerian orbit. Prior to Brady's work, Kiang [10] in 1971 had shown that observation dates obtained from *Chinese* records produced better raw material for reduction of residuals.

Brady introduced a purely secular term which reduced the residuals to a minimum (not zero) and then hunted through this term computer-wise to obtain the ephemerides of the hypothetical trans-Plutonian object. There is no "trickery" in this; it is quite legitimate to apply smoothing to orbital curves and then examine these cyclic residuals for they could contain the required information details on the unknown object.

Brady's optimised result required the "planet" to be orbiting at a distance of 63.5 A.U. with an orbital period of 464 years. The mass of the planet was quoted as "3 x that of Saturn" which approximates to 0.9 of that of Jupiter. But the optimal curve required the motion to be retrograde (i.e. reversed), and the orbital inclination to be 120° to the ecliptic. This aroused considerable skepticism [11] and photographs of the area failed to reveal any signs of a planetary object.

Finally in 1973 Kiang [12] showed that the cyclic residuals produced by smoothing were not due to a trans-Plutonian planet but were in fact an inherent property of the Sun-Jupiter-Halley system. The maths is "heavy going" but by two separate methods Kiang proved that this 3-body system had a natural period of oscillation which is approximately 8.6 times the period of Halley's comet, i.e. about 650 years (Kiang for convenience in analysis works to a scaled "short year" of just over 361 days. On this scaling Halley's comet has a period of 78 "short years", the whole system has an oscillation period of 676.26 "short years", and Jupiter has made 52 orbits of 13 "short years" each). Kiang's analysis is exact, and allows additional observations.

There is no detectable forced component in the solution; which means that if there *is* a trans-Plutonian planet which is perturbing the system, it is lost in the "noise" of the pendulum swing of the Sun-Jupiter-Halley oscillation. Similar arguments apply to other comets quoted by Brady as supporting the mass and orbital data deduced in his original work.

In Ref. 5, Lawton has suggested the possibility of studying the perturbations of *Chiron* as a means of determining the emphemerides of a tenth planet from the residuals of such a small body. Present data for such a task is minimal, and as Table 2 shows, there are resonances with the major planets which must be taken into account.

However, Chiron's orbit is almost circular and of a reasonably short period. Consequently the pendulum effect detailed by Kiang may be much reduced. Under such conditions, the effects of a 10th planet may just be discernible above the system "noise", but I am fully aware

TABLE 2. Resonances of Chiron and the Major Planets

CHIRON		JUPITER		SATURN		URANUS		NEPTUNE	
Orbits	Years	Orbits	Years	Orbits	Years	Orbits	Years	Orbits	Years
1	51	5	59.3	2	58.9	0.6	50.4	0.33	55
3	153	13	154.2	5	147	2	168	1	165
9	459	39	462	15	442	5.5	462	2.5	413
11	561	47	557	19	560	7	588	3.33	551
15	765	64	760	26	766	9	756	4.5	742.5

that I am being extremely optimistic in stating such a case.

Kiang went on to point out that Halley's comet was probably captured by Jupiter and thrown into its present orbit not more than 7,000 years ago and most probably less than that. This spectacular object has thus passed through the Solar System only some 80 to 100 times since it became a short period comet. This time can be historically related to the appearance of writing (early Sumerian). Unfortunately we cannot relate any Sumerian records to the above event. Although Jupiter may have been brilliant, the comet would have been insignificant at its time of capture.

Portrait of the Tenth

The near certainty that Pluto is not responsible for the perturbation of either Uranus or Neptune may trigger off fresh efforts to locate the disturbing agent. An editorial note was added to Ref. 5 to the effect that Soviet astronomers were analysing the paths of certain far ranging comets which may be perturbed by such a planet. The first of these approaches is in 1982 and slight changes in the path will be looked for, as these may be clues to the planet's position. However, the problem must be tackled carefully and the chances are very slim indeed that the comet and "planet 10" will be so juxtapositioned as to cause detectable perturbation. Also the Soviet astronomers must be wary of falling into the Sun-Jupiter 'X' trap set by Kiang.

Planetary orbits tend to be coincident with the aphelion distances of comets. The orbit of Saturn marks the aphelion distance of Halley's comet (and about 6 more), Jupiter's orbit marks the furthest point of about 50. This is not accidental, and the agent responsible is the gravitational pull of the major planets. Five have been attributed to Pluto, but in view of the feeble pull exerted by that body, this indeed must be coincidence.

However, sixteen periodic comets with aphelion distances of approximately 11,500 million kilometres were known to Pickering in 1928 and formed part of his belief in the existence of planet 'P'. It is these comets with aphelia beyond Pluto that will be the subjects of Soviet study. The quoted distance is about 75 A.U. and as such would fit the next niche in Bode's "Law".

A more promising approach was adopted by Rawlins and Hammerton in 1973 [13]. These workers "surveyed" and mapped out the most promising areas of sky for photography and blink microscope comparison. They also delineated the orbital distances and corresponding mass of the hypothetical perturbing planet, for there are several combinations of these two parameters which can yield the same observed perturbation. Rawlins and Hammerton have been thorough, but they highlighted three problems, one of which has been solved, another may be near solution but the third may be insoluble unless any further historical records of telescopic observations come to light.

Their first problem was assigning mass perturbation criteria to Pluto. In the absence of a satellite they assigned a mass of $^1/_{40}$ that of the Earth to Pluto; now we know from the discovery of Charon that the figure is closer to $^1/_{380}$. However the error is not serious.

The more serious second problem is that the mass of Neptune when determined by the orbital characteristics of its satellites differs by some 2.5% from the value determined by the motion of Uranus. The authors sidestepped the problem by introducing Neptune's mass as an extra unknown in the final differential equation.

The third problem is the orbit of Neptune itself. Since its discovery in 1846, the planet has not completed an orbit and will not do so until 2011. To date (1978) it has completed 80% of its near circular path.

If we include two prediscovery observations made by Lalande on the 8th and 10th May 1795 then we have more than a complete orbit (164.8 years) *but* we have an error of 7 seconds arc, an error that was repeated. (For reasons of accuracy Rawlins and Hammerton discard the observation made by Lamond on 25th October 1845).

Such an error is not likely; according to the authors they suggest a probability of less than 0.01 for such a repetitive coincidence. In particular Rawlins had made a detailed study of the elimination of systematic error on Lalande's 1795 observations.

The most promising solutions are show in Table 3.

TABLE 3. Limits of Solutions for a Possible Tenth Planet.

Radius of Orbit (A.U.)	Longitude Limits (2 s.d.)	Mass ± 1 s.d.*	Mass Earth = 1
75	309 - 320 deg.	5 ± 2	4.8 - 11.2
60	322 - 343 deg.	3 ± 1	3.2 - 6.4
50	338 - 5 deg.	2 ± 1	1.6 - 4.8

* Epoch 1973; Mass is Sun/206265.

The comet aphelion criteria if applied would choose the top solution at 75 A.U. with a mass somewhere between 5 and 10 times that of Earth. The paper by Rawlins and Hammerton suggests that if such an object exists, it may have a magnitude of about 17 and goes on to point out that when Tombaugh searched the area in 1929-30 the hypothetical planet would have had a low declination which may have hindered good observation.

So as of 1973 the "portrait of the tenth" was of a modest planet rather than a gas giant. The diameter would be close to Lowell's estimate of 25,000 km - assuming a density of 2.0. If the density was that of Pluto then the diameter would be over 30,000 km.

Recent Developments

This portrait has not changed much over the last few years and so far there has not been any promising candidate to step forward and claim the title. However, the mysterious "planet 10" may have indulged in violence in its early life. Following Christy's announcement of Charon, Robert Harrington and Thomas van Flandern (also of Flagstaff Observatory) speculated on the events leading to the birth of Charon and Pluto. They postulate a 10th planet of some 3 or 4 Earth masses which grazed the system of Neptune and wrenched Pluto free. The tidal forces so formed created Charon and reversed Triton to its present retrograde orbit. The encounter modified the orbit of Planet 10 such that it moved further out. Harrington and van Flandern do not place any severe restraint on the ephemerides of the orbit, but suggest that the perturbing body is now 50 to 100 A.U. from the Sun and may be too dim to be noticed. A sketch of the event is shown in Fig. 2.

This is a modification of the earlier 'encounter' theories of Lyttleton and Kuiper which were produced to account for Pluto. The extra planet is introduced to provide for the energy gains and losses needed to eject Pluto, produce Charon and reverse Triton.

I would suggest an alternate scenario which considers Pluto to have been the satellite of Planet X. In this case, the 'gravitational whiplash' effect is produced by Neptune, and being the most massive body in the encounter is easily able to impart the necessary energy to set Pluto free. This two stage mechanism may be more feasible than the "single shot nine pin" mechanism proposed by Harrington and van Flandern.

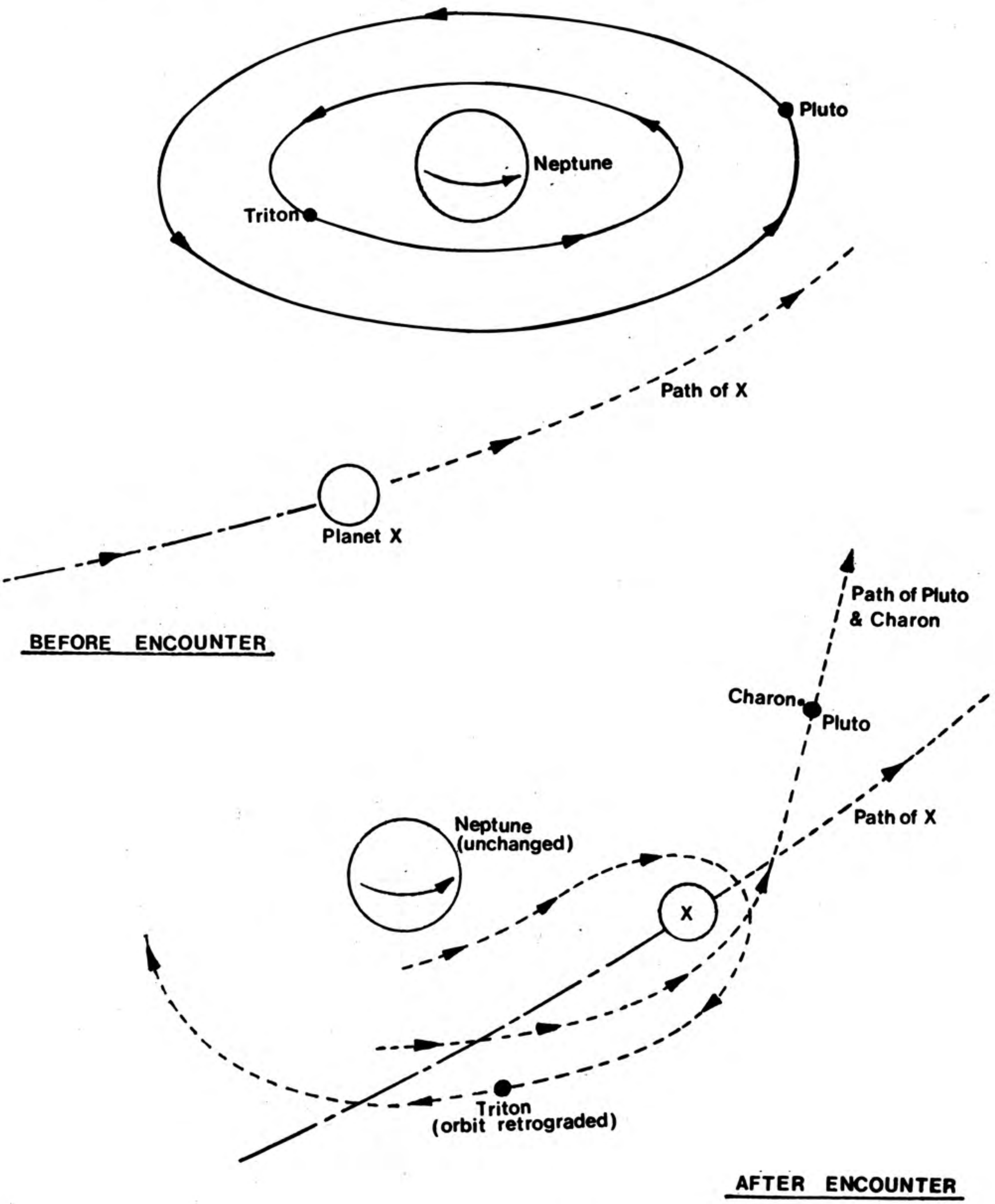


Fig. 2. A close encounter between a possible proto-system of Neptune and another planet ('X') may have caused the projection of Pluto unto a separate orbit around the Sun. The near collision also split the Plutonian prototype into Pluto and its companion Charon. Triton is thought to have originally orbited in a normal direction, but the momentum exchange between 'X' and Triton caused the latter to swing round the planet and thus acquire a retrograde (reversed) orbit. The mass differences between 'X' and Triton and Pluto are large (2400-1). It is therefore likely that 'X' was not seriously perturbed in its orbital movement. Neptune's second satellite Nereid has not been included in the sketch. Pluto has not been depicted as a satellite of the proto-Neptunian system. The alternative of Pluto and Charon being satellites of 'X' is not shown.

Drawings copyright A. T. Lawton

Table 4. Resonance Criteria for a Hypothetical Tenth Planet*

Planet	Neptune			Pluto			'X'	
No of Orbits	1	3	6	1	2	4	1	2
Period (Years)	164.8	*494.4*	988.8	247.7	*495.4*	990.8	*495*	990
Mean Distance AU	30	-	-	39.44	-	-	62.5	99

* The preferred resonance figures are italicised.

Return of Planet X?

At present the above theories are merely little more than ideas. If further observation of Charon and Pluto yields more data then there may be a firmer platform on which to work. In particular, a search for additional satellites of Neptune would be helpful. Photographic plate sensitivities have improved considerably since Kuiper discovered Nereid, the outermost satellite, found in 1949. If a search fails to reveal any other bodies of (say) 200-300 km in diameter then perhaps an "encounter" did take place and swept everything out of the Neptunian system with the exception of Triton and Nereid. On the other hand it is possible that the event left a large quantity of debris which is now spread around the planet in similar fashion to Uranus. Discovery of satellites or rings would also help to establish the mass of Neptune with better accuracy which, in turn, would improve the orbital residuals.

The explanation offered by Harrington and van Flandern could be extremely difficult to prove, but it might form a starting point for deducing possible orbits for 'Planet X'. If such a collision did take place then there is a probability that the orbit of the hypothetical planet will intersect that of Neptune in a similar manner to Pluto. This does not imply any further collisions, for the bodies concerned will undergo mutual perturbation and dynamically stabilise over a long period. The overall disturbances will be minimised and the system will be in equilibrium.

The orbital period of Pluto is in resonance with Neptune, and it can be easily shown that two orbits of Pluto are almost equal to three orbits of Neptune. Although Pluto crosses the orbit of Neptune – and for a period commencing in 1979 will cease to be the outermost planet, the system is in resonant equilibrium; only one planet occupies a given space at a given time.

If the Harrington-van Flandern collision occurred shortly after the Solar System was formed then there has been adequate time for a further body to have reached equilibrium. The most simple way in which a further body could be stabilised would be for the planet to execute a single orbit with a period equal to two of Pluto and three of Neptune. This resonance effect is clearly shown in Table 4, which also indicates the mean distance of 'X' in A.U.

I have deliberately included a second harmonic equilibrium orbital period (990 years) for although unlikely it cannot be altogether dismissed. But the 495 year period is the most simple system with unconditional stability and would therefore be the most likely one encountered. As shown in Table 4 this corresponds to a mean distance from the Sun of 62.5 A.U. which is within the limits laid down by Rawlins and Hammerton and shown in Table 3. The earlier assumption of intersection with the orbit of Neptune dictates a perihelion distance of approximately 30 A.U. This gives an aphelion distance of approximately 92.5 A.U. and an eccentricity of 0.35. If this be the case, Planet X will have the largest orbital eccentricity of any major body in the Solar System. The second harmonic mean orbital distance of 99 A.U. (as shown in Table 4) combined with a perihelion distance of 30 A.U. gives an aphelion distance of 170 A.U. This highly eccentric orbit (e = 0.7) might possibly be unstable. Rawlins and Hammerton suggest an upper limit of 600 A.U. for the Solar System. Beyond this, a planet might be set adrift by passing stars. The shorter period orbit is therefore preferable for long term stability.

The portrait that is beginning to appear in outline is that of a planet of moderate mass (5 x Earth) moving in a highly eccentric orbit (e = 0.35) with a period of 495 years at a mean distance of 62.5 A.U. This does not strictly conform to Bode's Law (which would require it to be at 77 A.U.) but if Harrington and van Flandern *are* correct in their theory of the formation of Charon and Pluto, the particular planetary configuration possibly indicated by Bode's Law was lost due to such collisions, and orderly relationship breaks down beyond 30 A.U.

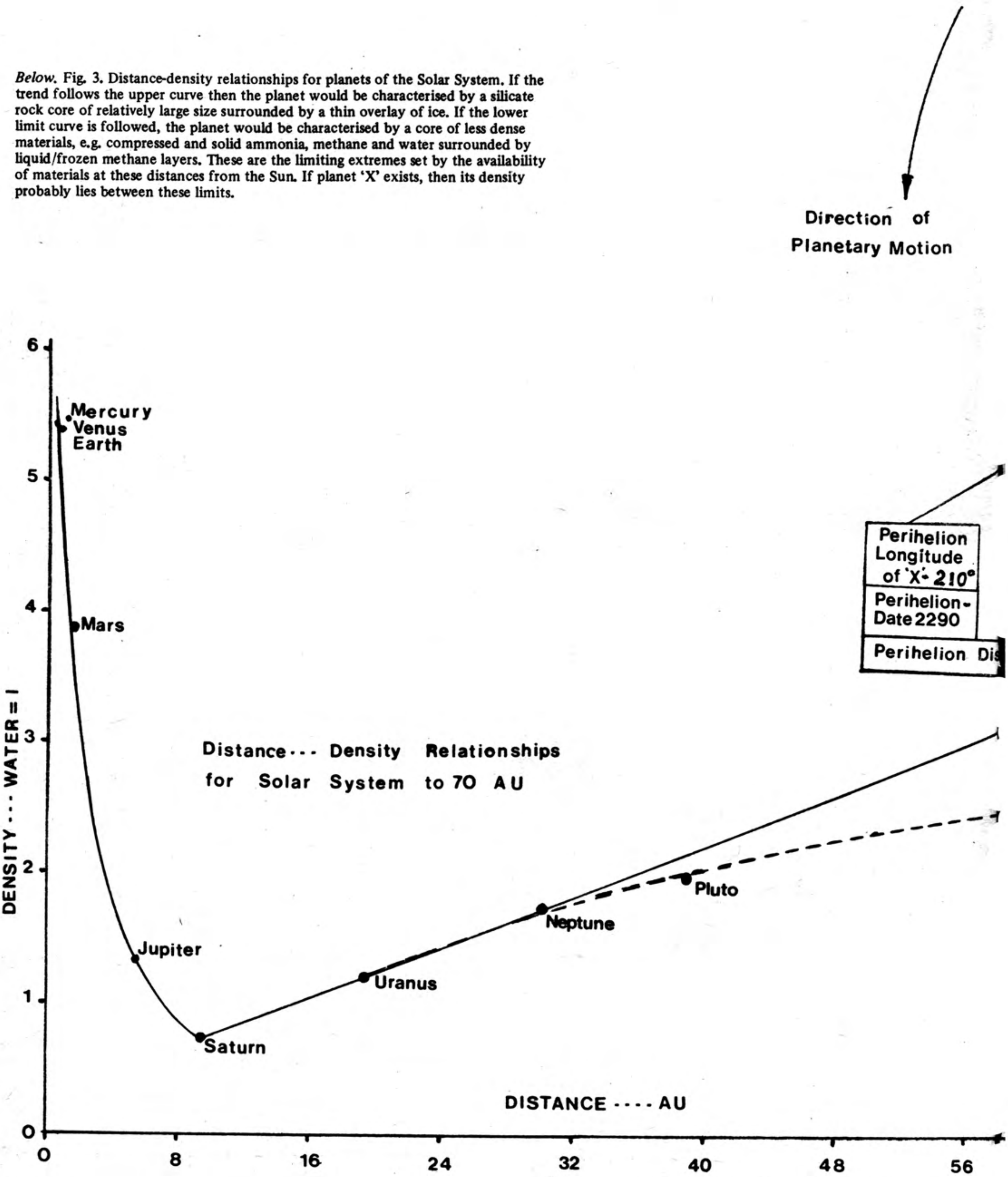
How Bright Would Planet X Be?

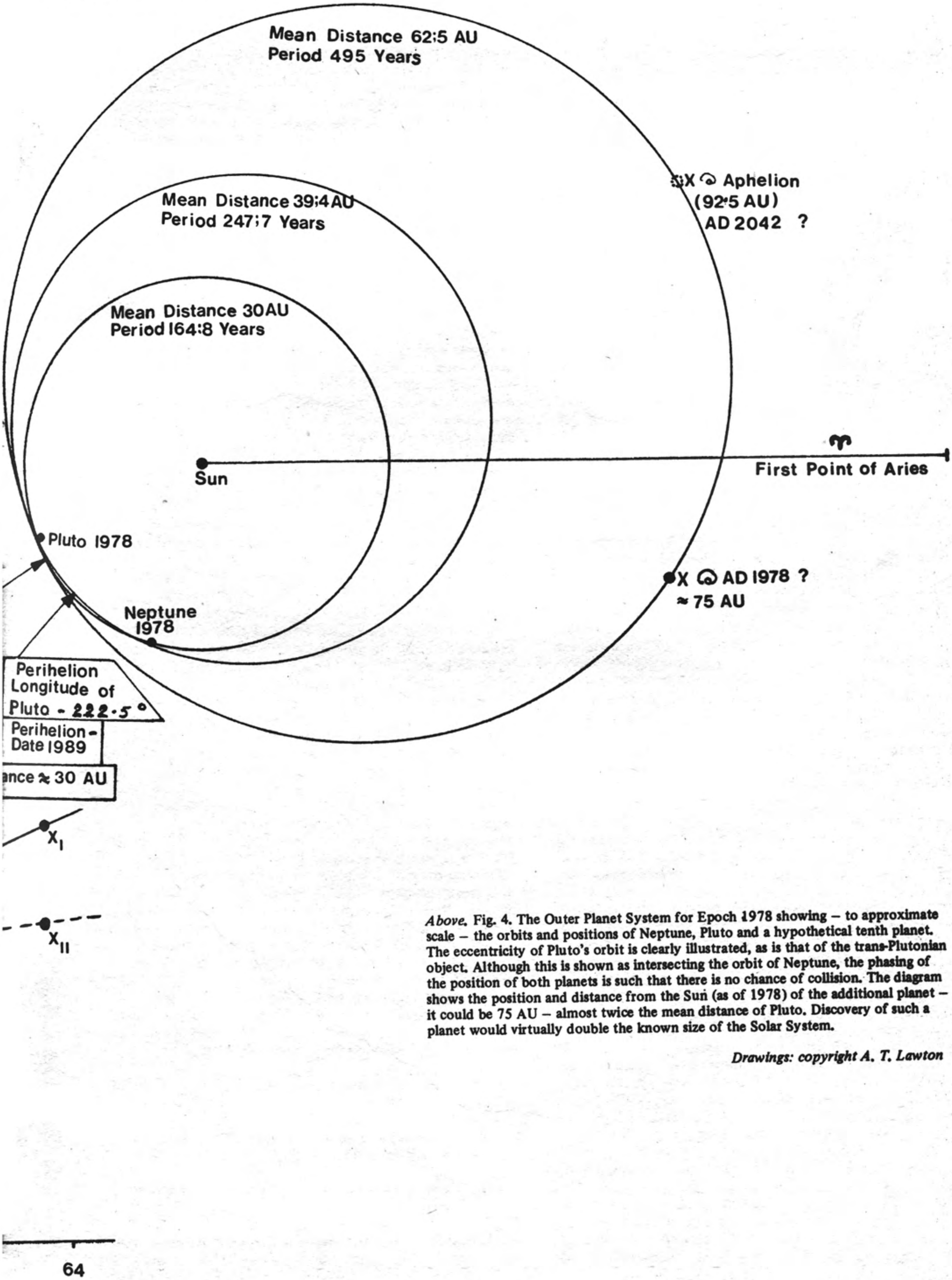
This depends on the composition of the planet's surface, the diameter of the planet, and the distance of the planet from the Sun. If we are dealing with an orbit of high eccentricity (as predicted in the preceding sections) then at perihelion (30 A.U.) the planet would be 90 times brighter than at aphelion (92.5 A.U.). This is because we are dealing with *reflected* light which follows a fourth power law ($L_R \propto d^4$) with distance 'd'. This is a brightness increase of 4.9 magnitudes. Clearly our best chances of finding the planet are at perihelion.

The diameter of the planet depends on its density, and (as stated earlier) if the hypothetical X has a density similar to Pluto then its diameter would be over 30,000 km. If the planet had a density similar to Neptune (1.7) then the diameter would be approximately 22,000-25,000 km. It would thus be about half the diameter of Neptune and have approximately one quarter the reflecting area. If it has the same albedo as Neptune (α = 0.84) it should be intrinsically four times (1.5 mag.) less bright. Neptune has a magnitude of +7.8 at its most brilliant. Therefore at perihelion the magnitude of Planet X should be approximately +9.3 and at aphelion +14.2.

Lowell quoted +12 and +13 in tabulating his estimates for magnitude and was quite clearly expecting a moderate sized planet with a reasonably high albedo. When discovered, Pluto was less bright than expected (mag. 14.5). Since original estimates of diameter were uncertain, and Pluto was thought to be almost as massive as Earth, initial figures for albedo were low, 0.14 being typical [14]. Now

Below. Fig. 3. Distance-density relationships for planets of the Solar System. If the trend follows the upper curve then the planet would be characterised by a silicate rock core of relatively large size surrounded by a thin overlay of ice. If the lower limit curve is followed, the planet would be characterised by a core of less dense materials, e.g. compressed and solid ammonia, methane and water surrounded by liquid/frozen methane layers. These are the limiting extremes set by the availability of materials at these distances from the Sun. If planet 'X' exists, then its density probably lies between these limits.





Above. Fig. 4. The Outer Planet System for Epoch 1978 showing – to approximate scale – the orbits and positions of Neptune, Pluto and a hypothetical tenth planet. The eccentricity of Pluto's orbit is clearly illustrated, as is that of the trans-Plutonian object. Although this is shown as intersecting the orbit of Neptune, the phasing of the position of both planets is such that there is no chance of collision. The diagram shows the position and distance from the Sun (as of 1978) of the additional planet – it could be 75 AU – almost twice the mean distance of Pluto. Discovery of such a planet would virtually double the known size of the Solar System.

Drawings: copyright A. T. Lawton

that the diameter has been more accurately determined and shown to be smaller than that of our Moon, the albedo of Pluto has been raised to 0.60 to account for the observed magnitude.

If Planet X really exists, and has the mass attributed to it in Table 4, then it cannot have an albedo similar to that of Neptune or Pluto. If that were so, it should have been found as a result of the extensive searches carried out by Tombaugh both before and after the discovery of Pluto. Either it is not in the predicted area, or it is very much darker than expected. This might demand a different surface composition to that of Neptune or Pluto, or alternatively the hypothetical planet may be more dense than Uranus and Neptune, and therefore smaller, the reduced area reflecting less light for a given albedo. There might be some evidence that this could be the case. Fig. 3 depicts the density-distance relationships for the planets of the Solar System, with the distance coordinate extended to 70 A.U. This embraces the expected mean orbit of Planet X.

If Pluto is ignored, the density-distance relationship follows the upper solid line and indicates that at 62.5 A.U. the mean density would be approximately 3.3 (position X_1). A planet with this value would probably be largely composed of a silicate/carbon chondrite rocky core with an icy overmantle. On the other hand if Pluto *is* included, the relationship follows the broken line. This has a much lower slope, and at 62.5 A.U. is almost horizontal with a mean density of approximately 2.6 (position X_{11}). For a given mass such a planet would have a small core of silicate and a large overmantle of ice and of course tend to be of larger diameter. Both paths of development are possible.

Taking this increased density into account, the diameter of the planet would be approximately 15-18 km. For the same albedo, the brightness would be down by magnitude 1. If the surface of X were similar to that of Pluto (frozen methane) as opposed to Neptune (gaseous methane) there would be a further decrease of magnitude 0.5. Adding these revised lower levels to the previous figures gives magnitude 10.8 at perihelion and 15.7 at aphelion. Should Planet X exist, then it may possibly be visible as an object with brightness of magnitude 11-16. Rawlins and Hammerton [13] suggested magnitude 17 obtained by using the lower limits of mass criteria given in Table 3.

Where is Planet X?

To postulate a planet with the above characteristics is easy, for it is speculation based on very slender evidence. The data is far more tenuous than that which formed the basis of Adams' and Leverrier's calculations and resulted in the discovery of Neptune by Galle. In that instance the measured discrepancy in the orbit of Uranus amounted to about 20 arc seconds – well outside the limits of error expected of good contemporary instruments in the hands of competent observers and mathematicians. Also, both Adams and Leverrier assumed that the unknown planet was orbiting close to the plane of ecliptic and conforming to Bode's Law. In fact they were lucky, for although it does not strictly conform to these rules, Neptune does have a near circular orbit, and R. A. Lyttleton (Cambridge UK) showed that had they made this assumption, the calculations would have been simpler and more accurate [15]. The calculations of Adams and Leverrier *were correct only for the year 1846.* Their calculations of orbit and future positions were entirely wrong – and only continuous and methodical observation provided the correct data and the presently established ephemerides.

Calculations for Pluto resulted in its discovery (approximately five degrees from the predicted position) but the perturbations of Uranus were very small compared with the errors of measurement. E. W. Brown in particular (as cited by Jones [16]) showed that fictitious elements of an unknown body can be obtained when adjusting orbital properties to give the lowest residuals of Uranus. Despite popular history, the truth could be that the discovery of Pluto owed more to the discriminating power of the blink microscope than to the accuracy of the maths. This seems to be increasingly supported by the known mass of Pluto being so low, 1/380 of Earth, as to be almost incapable of markedly perturbing Uranus (or even Neptune).

Much depends on the interpretation of the two observations by Lalande in 1795, which as stated previously appear to have errors. These are 7.2 arc secs in longitude and 1.2 arc secs in latitude. The observations were made on 8 and 10 May 1975. During the course of reducing his results to map coordinates, Lalande did not realise that the object had moved 40 secs of arc between the two observations or perhaps he alternatively considered the object to be a comet. (The heliocentric motion of Neptune is 20 secs per day; it was this that enabled Neptune to be identified as a planet within 24 hours of its discovery).

The difficulties of Lalande's observations are transferred to computations dealing with a possible orbit for Planet X. Rawlins and Hammerton found that if they were given a zero weighting the resultant residuals (and hence the unknown body's mass) were unrealistically high. In one significant passage, they quoted "If there is no body in the regions demarked – then (1) unless the hypothetical disturber's orbit is highly eccentric, the 1795 data must be flawed in some unknown way and (2) the possible mass of any circular orbit planet outside this area at reasonable distances is sufficiently restricted for our knowledge of the Solar System to be considerably enhanced." In other words if Lalande's sightings are correct, the body could be in an eccentric orbit and not in the forecast regions – or if it is in those regions it is so small that it is little more than an asteroid. If so, the Solar System stops at Pluto – or to be more exact, at Neptune, for Pluto is little more than a large asteroid or planetoid.

Although the accident thesis of Harrington and van Flandern can be criticised, it does offer the possibility of Planet X having an extremely eccentric orbit and therefore might admit of Lalande's observations being correct. The simplest – and most naive – assumption is that Planet X was close to Neptune during 1795 and caused the perturbation. By 1846 Neptune had moved approximately 111.4 degrees further on to where it was sighted in the constellation of Capricorn close to δ Cap. The more leisurely X moving at approximately 1/3rd this rate would have advanced only 37.1 degrees in the same time. If it had *also* been following close to the plane of the ecliptic, then in 1846 it might have been found in the constellation of *Ophuichus* about 1 degree from the 4th magnitude star ω Oph. If Planet X was nearing its perihelion in 1795 when Lalande sighted Neptune, then both planets were *angularly* close together in *Virgo* at that time. The nearest stars of any brightness were λ Vir and κ Vir both of 4th magnitude. Neptune passed through this region in late 1961 – and the measured perturbation residuals for *that* date are 180 times less than those for 1795. This suggests:-

(a) The errors are so large, the 1795 data is worthless.

(b) A perturbing agent was present in 1795 and absent in 1961.

(c) The data is flawed in some other and unknown way.

If Planet X were moving in a near-circular orbit close to the ecliptic, then simple extrapolation of the mean orbital

motion to 1978 should yield its present whereabouts. A simple prediction of this type gives a longitude of 345 degrees which places it in Aquarius close to the stars 96 Aqr, ϕ Aqr, 82 Aqr, 78 Aqr and λ Aqr. Since the orbit is possibly not circular but highly eccentric, and since our hypothetical 'X' may have some inclination to the ecliptic, the problem is not quite so simple. Nevertheless, the area I have mentioned *does* appear in the calculations in Ref. 13 and the work in based on the assumption of circular orbits. This is shown in Table 5 together with expected latitude positions. Note the wide range of Latitude values for 1 standard deviation. They do not imply a high degree of confidence.

TABLE 5

Radius of orbit	Longitude	Latitude ± 1 s. d.
75 A U	320°	- 27° ± 40°
60 A U	320°	+ 6° ± 8°
60 A U	340°	+ 30° ± 17°

If such a planet is orbiting in the implied area, then its present 1979 distance will approximate to 75 A.U., since it will not reach aphelion (92.5 A.U.) until AD 2042. A section of longitude and latitude values for 75 A.U. has therefore been included. Combining these figures gives a search area of :-

Longitude 320° to 340°	}	Total search area
Latitude +13° to -67°	}	20° x 70°

This is a large slice of sky, and its size represents our present lack of accurate perturbation data. This is not surprising for as shown in Fig. 4, these coordinates show that Planet X might be approaching conjunction on the "far" side of the Sun and not in the right area for producing strong perturbations. Neptune and 'X' may not again be in the same area (Virgo) until AD 2290. But until this region *is* thoroughly searched we will not know the boundary of the Solar System.

The "Elements" of the Tenth Planet

The "elements" and "ephemerides" of the hypothetical 10th Planet culled from all the scant evidence available might possibly be as follows:-

Mean distance (A.U.)	62.5		
Period (years)	495		
Eccentricity (e)	0.35		
Perihelion (A.U.)	30		
Aphelion (A.U.)	92.5		
Longitude of perihelion	210°		
Date of perihelion	2290		
Longitude 1978 October	330°	± 10°	Present constellation Aquarius (1978)
Latitude (± 1 s. d.)	+13°	- 67°	
Magnitude (perihelion)	11		
Magnitude (aphelion)	16		
Diameter (km x 10^3)	15 - 18		
Apparent diameter (perihelion	1 arc sec.		
Apparent diameter (aphelion)	0.3 arc sec.		
Mass (Earth = 1)	5 - 6		
Density (mean)	2.5 - 3.4		
Direction of orbital motion	– normal		
Surface temperature (mean)	-240°C		
Surface colour (perihelion)	Blue/Green		
Surface colour (aphelion)	Yellow/White		

The colour changes postulated are produced when the surface constituents change from gaseous methane to liquid, and finally solid methane, as the planet moves away from the Sun and cools down. The process is reversed as the planet returns to perihelion.

Conclusions

If the tenth planet exists it could be very much as depicted above. But all this speculation depends on the accuracy of one observation before Neptune was discovered – and a great deal of hard work if we have proof of the correctness of Lalande's critical sighting.

Archival searches *may* prove useful; history has always recorded that past observers sighted planets without recognising them. Uranus was the earliest example, and Chiron the most recent.

Perhaps Planet 10 does not exist and the Sun only rules over eight major planets, with Neptune at the frontier.

In either case our knowledge will have been increased, and we may have a little more insight into the peculiarities of the planetary systems of stars of a different type to our Sun. The behaviour of a planet such as the hypothetical 'X' may be very similar to that of a medium sized planet orbiting Barnard's Star at (say) 4 A.U.

Acknowledgement

The author is indebted to Dr. A. Fabian for criticism and helpful suggestions during the course of preparation of this article.

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WHERE ARE THEY NOW?

By David J. Shayler

PART FOUR

Group 6. Scientist Astronauts: 11 selected 4 August 1967

The sixth group of NASA astronauts, and second group of scientist astronauts, originated from requests made in September 1966, with requirements similar to those used in the selection of the first scientist astronaut group in 1965. The deadline for the applications was set for no later than midnight 8 January 1967, then following the now familiar selection procedure NASA would notify all successful candidates by no later than 30 June 1967. Nearly 500 applications were received and after reducing this number to 65 a joint NASA/National Academy of Sciences Selection Board selected the final 11 candidates.

The Astronauts:

ALLEN IV, Joseph P., Civilian , Dr. (Ph.D. Physics). Born 27 June 1937, Crawfordsville, Indiana. Married, two children. Support crew member and Mission Scientist Apollo 15; following a short term working on the Skylab programme he took temporary leave of absence in 1973 to serve on the Staff of the President's Council on International Economic Policy; also participated in NASA's Outlook for Space Study 1973-July, 1975; assigned Space Shuttle Development(Spacelab; payload support–crew stations, controls and displays for physical sciences). Since August 1975 has been engaged as Assistant Administrator for Legislative Affairs at NASA Headquarters, Washington, D.C. Available for Space Shuttle flights.

CHAPMAN, Philip K., Civilian, Dr. (Ph.D. Instrumentation). Born 5 March 1935, Melbourne, Australia. Married, two children. Became U.S. Citizen 8 May 1967; resigned NASA July 1972 to become Principal Research Scientist with AVCO Everett Research Laboratories, Everett, Massachusetts, and currently serves as a Senior Research Associate at the MIT Measuring Systems Laboratory, Cambridge, Massachusetts.

ENGLAND, Anthony W., Civilian, Dr. (Ph.D. Geology and Physics). Born 15 May 1942, Indianapolis, Indiana. Married, two children. Support Crew member and Mission Scientist Apollo 16; resigned NASA August 1972 to accept a position as Staff Geophysicist for Remote Sensing with the U.S. Geological Survey, Denver, Colorado. In 1973 he participated in geological aspects of the Skylab programme, serving temporarily on the mission control teams and as geological consultant to the astronauts.

HEINZE, Karl G., Civilian, Dr. (Ph.D. Astronomy). Born 17 October 1926, Cincinnati, Ohio. Married, four children. Support Crew member Apollo 15, Principal Investigator for Ultraviolet Astronomy Experiments (SO19) for the Skylab programme. Currently assigned to Space Shuttle duties (payload support–crew stations, controls and displays for the physical sciences), and development work on the Space Telescope.

HOLMQUEST, Donald L., Civilian, Dr. (Ph.D. Medicine and Physiology). Born 7 April, 1939, Dallas, Texas. Divorced, one child, subsequently remarried. Took a leave of absence in May 1971 to hold the position of Assistant Professor of Radiology and Physiology at Baylor College of Medicine. Resigned from NASA September 1973 to become Assistant Dean of the Medical School at Texas A&M University. He has subsequently resigned that position and set up his own practice, the Nuclear Medicine Laboratory, in Vavasota, Texas.

LENOIR, William B., Civilian, Dr. (Ph.D. Electrical Engineering). Born 14 March 1938, Miami, Florida. Married, two children. Backup Science Pilot for both Skylab 3 and Skylab 4; currently assigned Space Shuttle Development (payload support–crew stations, controls and displays for the physical sciences).

LLEWELLYN, John A., Civilian, Dr. (Ph.D. Chemistry). Born 22 April 1933, Cardiff, Wales. Married, three children. Became U.S. Citizen on 17 February 1966, the very first British-born astronaut; withdrew from NASA for personal reasons 6 September 1968 to take up a post as Chemistry Professor at Statue University of Florida, Tallahasse, Florida. He is currently a Professor in the Department of Energy Conversion and Mechanical Design, College of Engineering, University of South Florida.

MUSGRAVE, F. Story, Civilian, Dr. (Ph.D. Medicine and Physiology). Born 9 August 1935, Boston, Massachusetts. Married, five children. Backup Science Pilot Skylab 2; subsequently assigned Space Shuttle Development Work (payload support–crew stations, controls and displays for the life sciences).

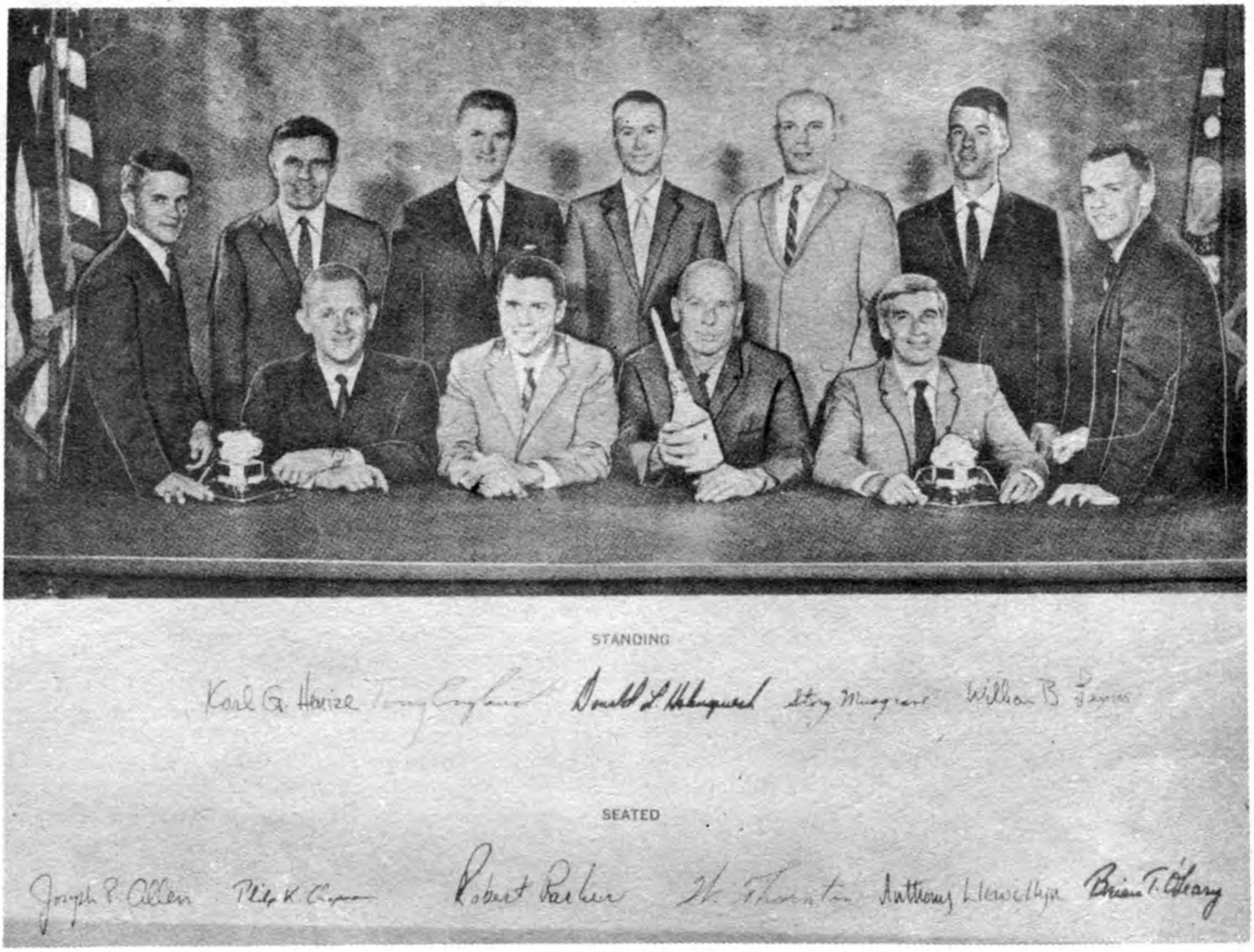
O'LEARY, Brian T., Civilian, Dr. (Ph.D. Astronomy). Born 27 January 1940, Boston, Massachusetts. Married, two children. Resigned for personal reasons in April 1968, and took a position on the Cornell University staff. He was an Assistant Professor of Astronomy and Science Policy Assessment at Hampshire College, Amhert, Massachusetts; became a special consultant on nuclear energy matters for the Committee on the Interior, U.S. House of Representatives, and is currently a Research Staff Member in the Department of Physics at Princeton University, Princeton, New Jersey; he is also working on plans for space colonization with Gerard O'Neil at Princeton.

PARKER, Robert A., Civilian, Dr. (Ph.D. Astronomy). Born 14 December 1936, New York City, New York. Married, two children. Support Crew member Apollo 15; Support Crew member and Mission Scientist Apollo 17; Chief Scientist for all three Skylab missions; became Chief of the Scientist Astronauts, JSC, in September, 1974. Served as Chairman of NASA's Editorial Review Board, and as Chief of the Science and Applications Astronaut Office for a short time. Currently assigned Space Shuttle development work; (payload support–crew stations, controls and displays for the physical sciences).

THORNTON, William E., Civilian, Dr. (Ph.D. Medicine). Born 14 April 1929, Faison, North Carolina. Married, two children. Member (Science Pilot) of the Skylab Medical Experiments Altitude Test; Support crew member Skylabs 2, 3 and 4; Principal Investigator for two Skylab Experiments, MO74 Specimen Mass Measurement and M172 Body Mass Measurement; subsequently assigned Space Shuttle development (payload support–crew stations, controls and displays for the life sciences). He has also participated as a mission specialist in three Spacelab-type simulations at JSC in October 1974, January 1976 and May 1977.

Group 7. Ex-MOL Pilot Astronauts: 7 selected 14 August 1969

The USAF Manned Orbiting Laboratory Program (MOL) had its beginnings in 1963, and was conceived primarily to determine the usefulness of man in his military role in space. The men who were to have flown MOL missions



SIXTH CLASS of astronautics selected and the second selected specifically for scientific education rather than pilot backgrounds. The six seated at table, left to right, are Joseph P. Allen, Philip K. Chapman, Robert A. Parker, William E. Thornton, John A. Llewellyn and Brian T. O'Leary. Standing, left to right, are Karl G. Heinze, Anthony W. England, Donald L. Holmquest, Franklin S. Musgrave and William B. Lenoir.

National Aeronautics and Space Administration

were selected in three groups (Group 1, 12 November 1965, 8 chosen; Group 2, 17 June 1966, 5 chosen; Group 3, 30 June 1967, 4 chosen). On 10 June 1969 the MOL programme was cancelled without a single manned flight taking place, mainly due to budget restrictions, and the USAF was forced to wait until the advent of the Space Shuttle in the 1980's to put its servicemen and women into space in active military roles. Of the 17 men chosen for the programme three are now dead, seven returned to the USAF and have now retired or are on other AF duties, and the remaining seven are serving NASA Astronauts. There were no selection qualifications issued this time since the men had already qualified under the Air Force Programme; it is these astronauts who will command the early Space Shuttle missions of the mid-to late 1980's.

The Astronauts:

BOBKO, Karol J., Lt. Colonel USAF. Born 23 December 1937, New York City, New York. Married, two children. Selected MOL programme Group 2 (17 June 1966); Crew Member (Pilot) Skylab Medical Experiment Altitude Test (SMEAT)-56 days; Support crew ASTP; currently assigned Space Shuttle development.

CRIPPEN, Robert L., Commander USN. Born 11 September 1937, Beaumont, Texas. Married, three children. MOL astronaut selected 17 June 1966 (Group 2); Commander SMEAT; Support Crew leader Skylab 2, 3 and 4; Astronaut Support Crew Cdr ASTP; subsequently assigned Shuttle development (Orbital flight tests – mission phase; hardware/software interface). In April 1978, named pilot lst manned Shuttle Orbital flight late 1979.

FULLERTON, Charles G., Lt. Colonel USAF. Born 11 October 1936, Rochester, New York. Married, two children. Group 2 (17 June 1966) MOL astronaut; Support Crew Member Apollo 14 and Apollo 17; assigned Space Shuttle Development (recovery – mission phase; controls and displays – hardware). Pilot Shuttle ALT Crew 1 Spring 1976 and, during 1977, flew the first and third manned captive flight and the first and third free-flight; in April 1978 he was named as one of the group of astronauts assigned to the Space Shuttle orbital test flight series in the 1979-80 period.

HARTSFIELD, Jr., Henry. W., Colonel USAF. Born 21 November 1933, Birmingham, Alabama. Married, two children. Group 2 MOL astronaut (17 June 1966); Support Crew Member Apollo 16, Skylab 2, 3 and 4; currently assigned Space Shuttle development (simulations; flight control systems–hardware). Retired USAF 31 August 1977.

THESE ASTRONAUTS formerly assigned to the United States Air Force's Manned Orbiting Laboratory programme, cancelled in 1969, constituted the seventh group of astronaut selected by the National Aeronautics and Space Administration. Announcement of their re-assignment was made in August 1969. The astronauts represent three branches of the military: Marine Corps, Air Force and Navy. They are, from left to right, Karol J. Bobko, Charles Gordon Fullerton, Henry W. Hartsfield, Jr., Robert L. Crippen, Donald H. Peterson, Richard H. Truly and Robert F. Overmyer.

National Aeronautics and Space Administration

OVERMYER, Robert F., Lt. Colonel USMC. Born 14 July 1936, Lorain, Ohio. Married, three children. Group 2 MOL astronaut(17 June 1966); Support crews Apollo 17 and Apollo 18 (ASTP); currently assigned Space Shuttle development.

PETERSON,Donald H., Colonel USAF. Born 22 October 1933, Winona, Mississippi. Married, three children. Group 3 MOL astronaut (30 June 1967); Support crew Apollo 16; currently assigned Space Shuttle development (on orbit systems–mission phase; navigation; communications and tracking hardware; reaction control systems/orbital manoeuvering systems hardware).

TRULY, Richard H., Commander USN. Born 12 November 1937, Fayette, Mississippi. Married, three children. Group 1 MOL astronaut (12 November 1965); Astronaut support member Skylab's 2, 3 and 4 and Apollo 18 (ASTP); assigned Space Shuttle development and in the Spring of 1976 was named Pilot of second ALT crew; flew second captive/active flight and second free flight during the ALT programme; April 1978 named as one of the group of astronauts training for first manned orbital missions in Shuttle flight programme; will also serve as backup Pilot first manned Shuttle flight, late 1979.

[To be continued.

VERTIKAL 7

The Soviet Union launched another geophysical rocket, Vertikal 7, from Kapastin Yar on 3 November at 1505 hrs (Moscow time), writes Neville Kidger. The stabilized instrument probe, which separated from the launch vehicle – a modified SS-5, 'Skean' – on the ascending leg of the trajectory at a height of 175 km, reached its zenith at about 1,500 km.

The objectives included research into the "complex exploration of the Earth's atmosphere and ionosphere as well as the interaction of the Sun's short-wave radiation with the atmosphere." Experiments were provided by the USSR, Bulgaria, Hungary, Romania and Czechoslovakia.

MISSIONS TO SALYUT 6

By Gordon R. Hooper

Continued from December 1978 issue, page 437]

PART 5

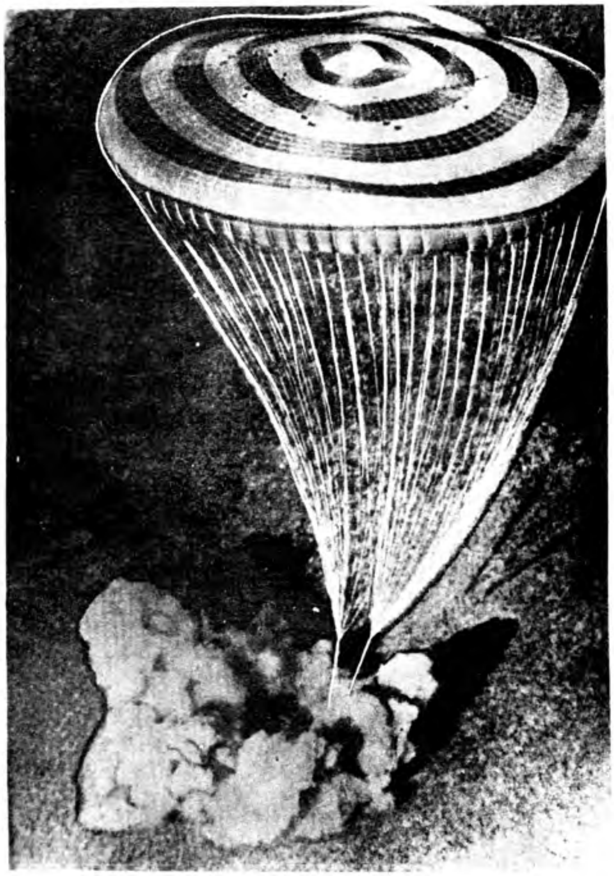
Soyuz 29

On 15 June 1978, at 20.16 and 45 seconds (all times expressed in GMT), the Soviet Union launched Soyuz 29, callsign Photon, carrying a two-man crew. The commander was Colonel Vladimir Kovalyonok, and the flight-engineer Alexander Ivanchenkov, a rookie cosmonaut. It will be remembered that Kovalyonok flew the first mission to Salyut 6 – Soyuz 25 – in October 1977. On that occasion, he and Valery Ryumin had to abort the mission owing to a faulty Soyuz docking mechanism.

The Soviet Press suggested that another record flight might be attempted. In a pre-flight press conference, Kovalyonok told *Izvestia*: "Very long and tense work lies ahead." Following a docking with Salyut 6, the crew would be continuing a whole series of experiments initiated by the previous Salyut 6 main crew of Yuri Romanenko and Georgi Grechko.

The flight programme envisaged:

- studies of the Earth's surface and atmosphere to obtain data of scientific and economic use;
- carrying out astrophysical experiments and investigations;
- technological experiments directed at obtaining new materials;
- biomedical studies;
- technical experiments and tests on the structure of the space station and on the onboard systems and instrumentation.



Retro-rockets ignite to cushion the landing of Valery Bykovsky and Sigmund Jähn aboard the Soyuz 29 capsule. They left their own Soyuz 31 spacecraft docked to Salyut 6 for the subsequent recovery of the long-stay cosmonauts Vladimir Kovalyonok and Alexander Ivanchenkov.

Panorama DDR/Zentralbild

By 09.00 on 16 June, Soyuz 29 had completed 9 revolutions. Following a trajectory correction, the parameters of the spacecraft's orbit were 314 x 270 km (195 x 168 miles) x 90 min. x 51.6°. Telemetry and the crews reports showed that all the systems were working normally and that the crew felt well.

When the Soyuz had got to within 22 km (14 miles) of the Salyut, the "Igla" (Needle) radio guidance system was switched on. Docking took place at 21.58, and was first reported by the Kettering Group, being confirmed some two hours later by *Tass*. The Soyuz docked at the forward Salyut docking port, and the crew spent several hours carrying out checks on the docking interface, and equalising the pressure in the Salyut and Soyuz craft. They then waited for a period of good TV reception before transferring to the Salyut, the transfer hatches opening automatically.

Upon entering the station, they were delighted to find a letter from Romanenko and Grechko. They then switched on the air regenerators and the "STR" thermo-regulating systems, before resting for a while, and then working on the water recycling system. Water had been left onboard since the previous expedition, and this had to be reprocessed.

The new crew sent a message of greetings to the listeners of Radio Moscow all over the world. "Dear Radio Moscow listeners," said Vladimir Kovalyonok, "we've been spinning around the Earth, circle by circle, seeing the planet and wondering how wonderful and small it is. May all our flights, all our accomplishments on Earth and in space always serve one of the most cherished causes of peace. It is this goal that the Soviet Union pursues in its exploration of outer space."

"All the experiments we are carrying out in orbit are geared to the solution of national economic tasks," said Alexander Ivanchenkov. "They pursue exclusively peaceful goals in the interests of not only this country."

On 18 June, the crew re-activated several research instruments. In a telecast they said they were feeling fine and that all systems were functioning properly. The home service of Radio Moscow reported that the de-mothballing of Salyut 6 would take a few more days. MCC was trying to keep the crew's workload to a minimum during the period of adaptation to weightlessness. The crew's doctor, Robert Vasilyevich Dyakonov, said the cosmonauts were adapting more easily than the *Tamyr* crew, (i.e. Romanenko and Grechko). "Naturally," he said "the *Tamyr* crew's recommendations have been taken into account, for example, that the "Pingvin" (Penguin) suits should be worn from the very first hours in the station.

The second point, based on their predecessors experience, is that the minimum amount of de-mothballing work should be done during the first days in the station. They are working at their own discretion, doing what they consider necessary. The initial period of adaptation took 3 to 7 days with the *Tamyr* crew. In the case of the present crew this period is expected to last only 3 to 4 days of flying time, in view of their performance in training," he concluded.

In an interview with Radio Moscow, Prof. Alexander Ivanovich Lazarev of the Leningrad State Optical Institute

said that the new crew would be continuing observations made by the previous Salyut crew. One programme of observations of atmospheric optical phenomenon had been delivered by Dzhanibekov and Makarov at Georgi Grechko's request – it had been left onboard the station and would be used by the new crew. "We have asked the cosmonauts to pay attention to observation of the vertical ray structure in the second emission layer," said Prof. Lazarev. These phenomena had first been observed by Vitaly Sevastyanov on Salyut 4.

The first crew onboard Salyut 6 were unfortunately unable to carry out these observations (no details were given) and so the second crew had been asked to pay particular attention to these observations. Attention would also be given to the movement of noctiluscent clouds.

The new crew would also continue the observations begun by Grechko onboard Salyut 4, of the points at which the planets rose and set on the Earth's horizon.

On 19 June, the parameters of the Salyut's orbit were 368 x 338 km (229 x 210 miles) x 90.4 min x 51.6°. The parameters of the micro-climate were: temperature 20°C (68°F) and pressure 780 mm on the mercury column. During the day, the crew continued de-mothballing the Salyut, and de-activating the Soyuz ferry. As part of their medical programme, they made body-weight measurements using a massmeter. Following the recommendations of Romanenko and Grechko, the new Salyut crew were working according to a new timetable. Their working week was now a five day one, with weekends free. Each working day began at 8.00 Moscow time, and ended at 23.00. This allowed them an increased sleeping time of nine hours.

On 20 June, Radio Moscow reported that doctors were pleased with the condition of the cosmonauts based on information received regularly *via* telemetry. The two men spent the day de-mothballing the Salyut, conducting medical investigations, preparing for photography of the Earth, and checking the conditions of weightlessness under which various alloys were to be obtained.

Selection of Polish Cosmonaut

Radio Warsaw carried a feature on the selection of Poland's first cosmonaut, saying that he would be launched "any day now." Drawing upon the vast experience of the US and USSR in astronaut/cosmonaut selection, the Polish specialists concentrated their selection on military pilots. The initial choice was made in the Military Institute for Air Force Medicine and Psychology, where the basic criteria for selection had been worked out.

From the existing medical documents, records and personal data avaialable on Polish military pilots, a few thousand candidates were picked out and subjected to very stringent and exhaustive tests. Finally, the number of men was reduced to just a few, who were brought before a special commission of Soviet and Polish experts. Based on the commissions findings, the Polish experts chose two men to be sent for cosmonaut training in the Soviet Union.

On 21 June, at 06.00, Salyut 6 entered the radio visibility zone of the research ships *Academician Sergei Korolyov, Kosmonaut Vladimir Komarov,* and *Kosmonaut Pavel Belyayev.* The Salyut crew spent the day de-mothballing and preparing the scientific equipment for forthcoming research. They carried out visual observations, including those of noctiluscent clouds over the Antarctic. They also started a programme of brief physical exercise in accordance with doctors recommendations, and carried out a comprehensive test of their blood circulation.

The experiments with drosophila fruit flies begun on the previous expedition had been resumed, and other experiments with instruments were to be carried out to study the effects of weightlessness on their organisms.

Radio Moscow reported that it had been the last day of de-mothballing and all scientific equipment should now be in a state of readiness. The re-activation of the life-support, power supply and temperature control systems had been completed. The crew had carried out the checking of the portholes, control panels of the scientific apparatus, and carried out initial tests on the propulsion system responsible for the orientation of the station. It was tested in both automatic and manual modes.

Radio Warsaw reported that the flight of Soyuz 29-Salyut 6 station was arousing tremendous interest in Poland, because "a Polish cosmonaut was to be launched to it very shortly."

On 22 June, a routine orbital correction was made. "The station's service propulsion engines were controlled from Earth by radio. Since the crew had medical research to do.... they carried on with their work and the correction was made from Earth. This was the first time this had been done," reported Radio Moscow.

The medical research included a series of comprehensive research on the cardiovascular system. The de-mothballing of the massmeter was also completed during the day. Tests showed the cosmonauts were both in good health. The pulse rates of Kovalyonok and Ivenchenkov were 60 and 55 respectively, while blood pressures were 120/60 and 125/65. Doctors reported that the two men were adjusting to weightlessness quicker than the previous crew.

The cosmonauts installed some of the equipment they had brought from Earth for improving the living conditions onboard, to make the station more comfortable. They were also "carrying out other work in accordance with onboard documentation based on the experience of the previous flight and which brought about certain alterations in the present flight programme." They also replaced a defective ventilator on the "Splav" (Alloy) furnace, and performed maintenance on the Salyut's airlock. They then prepared the furnace for technological experiments.

In a communications session, the cosmonauts said that at present the Sun could be observed without using a light filter. It did not rise or set, but just rolled around on the horizon. Radio Moscow broadcast a comment by Vsevolod Alexandrovich Ivanoc, of the Space Research Institute, on the cosmonaut's observations of the Sun. He said Salyut 6 was in an unusual orbit – a solar orbit – with the Sun constantly visible. The atmosphere was concealing the Sun's bright colours, and this unique phenomenon also had an effect on observations of the Earth. It was in fact the indirect rays of the Sun which enabled one to make out certain special features in observations. The cosmonauts had spoken about an unusual and interesting phenomenon, which still needed to be checked and investigated.

They said that while flying over the Pacific, they had seen "some very large underwater ridges." Changes in currents often occurred near ridges, and such a formation on the ocean bed often influenced the whole life of the ocean. This phenomenon had only become visible because of the change in its illumination. During the present flight, the special position of the Sun would make it possible to discover new and unique phenomena.

On 23 June 1978, the crew conducted tests of the "Kaskad" (Cascade) orientation system and also made the station more comfortable by adjusting temperature and humidity. They also carried out medical checks, including experiments to study the dynamics of blood circulation. The cosmonauts carried out a series of studies to test the reaction of the cardiovascular system to simulated hydrostatic pressure using the "Chibis" (Lapwing) pressurised suit. They had also examined the circulatory system at rest, measured each others body mass and carried out other experiments.

A three-day smelting experiment was also begun, with the Salyut in a gravity-gradient stabilised mode, with the

automatic thrusters disengaged to prevent any interference with the materials being processed. The "routine technological experiment" aimed to produce an alloy of cadmium telluride and mercury telluride. The first known crystal of this semi-conductor had been obtained by Romanenko and Grechko.

On 24 June, the crew had a day of active rest. The reason for introducing the five day working week was that Romanenko and Grechko had found that they didn't have enough time for their personal needs and for keeping up with paperwork. Therefore, on 24 June Kovalyonok and Ivanchenkov put their log books and technical documents in order. They also kept an eye on the Splav smelting experiment begun the previous day.

First Week's Work

In a communications session, the cosmonauts reviewed their first week's work. Vladimir Kovalyonok said "A great deal of work has been done during these days. We have made thorough and searching checks of the systems serviceability, and it is gratifying to note that we have no criticisms; all systems, all units, all instruments, all equipment are functioning normally. The impression made by this immense, multi-tonne complex beginning to submit to your decision to your will, is gripping – just a millimetre's movement of the control stick, and the station starts to obey; it is very responsive, and the instruments make it possible to orientate with great precision."

On 25 June, the cosmonauts had their second rest day. They checked the complex's systems, "an obligatory morning task," then had breakfast, and carried out medical checks, and did physical exercises. They also wrote up their logs and technical documentation.

They watched films, read and listened to music. In a communications session, Ivanchenkov said he was sorry that he hadn't taken his guitar with him. MCC then promised that it would be sent up to him onboard "a ship due to visit the station." (This promise was in fact kept, with the launch of Progress 3).

On 26 June, the Salyut crew readied their telescope for work, checking its cryogenic cooling system. They also studied plant growth in zero-g, growing onions, and also mushrooms. They found that their gardening reduced psychological stress.

On 27 June, *Novosti* reported that before their flight, Kovalyonok and Ivanchenkov received intensive training in ground observation from space. They had lessons from experts in geological and scientific observations from onboard a Tu-134 flying laboratory. The plane flew at 9000 m (9 km) (9842 yards or 5.6 miles) while glaciologists, oil specialists, geologists and others explained to them the features which interested their particular branch of science. The cosmonauts, said *Novosti*, had 15 specific assignments to carry out.

Soyuz 30

On 27 June, at 15.27, the Soviet Union launched Soyuz 30, callsign "Kavkaz" (Caucasus), carrying a two-man crew. The commander was Colonel Pyotr Klimuk, who had previously flown as commander of Soyuz 13 and 18, in 1973 and 1975 respectively. His companion on Soyuz 30 was Polish cosmonaut-researcher Major Miroslaw Hermaszewski. This was the second mission to take place under the Intercosmos programme (see Missions to Salyut 6, Part 4), and the crew would be spending seven days onboard the Salyut station. Back-up commander was Valeri Kubasov, and back-up researcher, Zenon Jankowski.

The Polish delegation at Tyuratam/Leninsk included the Polish Defence Minister General Wojciech Jaruzelski, a member of the Politburo, together with Andrzej Werblan, Secretary of the Polish United Workers Party Central Committee, Kazimierz Olszewski, Polish Ambassador to the Soviet Union, and Witold Nowacki, President of the Polish Academy of Sciences. General Jaruzelski said in a speech at Tyuratam/Leninsk, "We have been witnesses to a great event. A moment ago, the first ever Soviet-Polish crew was launched from this famous site into Earth-orbit, to take part in research and exploration of outer space, which have become important factors in shaping this new era of our civilisation."

"I would like to convey to them (the Soviet engineers and designers, etc.) our sincere words of gratitude and congratulations on behalf of the Polish United Workers Party, the supreme authorities of the Polish people and personally on behalf of Mr. Edvard Guerik.... For us, this is a contemporary and particularly valuable expression of internationalism, as well as an opportunity to speed up the economic and technological development of our countries, to make them still more prosperous. We feel deeply and patriotically proud that the first Pole.... through his participation in the Intercosmos programme will be performing a highly responsible duty. And that all this will take place shortly before Poland's national holiday (i.e., 22 July) in the year which marks the 35th Anniversary of the Polish People's Army."

The Polish leaders, Edvard Guerik, President Hendrich Jablonski, and Premier Pyotr Jaroszewicz sent a message to Brezhnev and Kosygin. In it, they offered their congratulations on the launch of Soyuz 30. The message stressed the delight with which the Polish nation and the Polish United Workers Party received the news of the successful start to the mission. Guerik also sent flowers and messages of greetings to the mothers of the two Polish cosmonauts.

At the pre-flight press conference, Hermaszewski said that he would be taking with him onboard Soyuz 30 a Gold Medal from the Child Health Centre, a hospital monument currently being commissioned near Warsaw, and built in memory of the 13 million children who lost their lives during the Second World War.

Hermaszewski expressed the hope that the flight would be of use to the Polish economy. This was the aim of the Polish designed experiments, he said. He thanked the Soviet government and the Polish government for the trust placed in him.

The Soyuz 30 crew had, by 24.00, completed all the necessary operations after going into orbit. A communications session was held at 07.00 on 28 June, and at 13.00, when the Soyuz had completed 14 revolutions around the Earth, a trajectory correction was made. The parameters of the orbit were then 310 x 264 km (193 x 164 miles) x 90 min x 51.6°.

The Soyuz then closed on the Salyut, and docked at 17.08 at the aft docking unit. The operation was carried out with "precision and harmony," and was the sixth successful docking with the Salyut station. At 20.10, Hermaszewski passed through the transfer hatch and was embraced by Kovalyonok. He was followed by Klimuk, and the new cosmonauts were presented with bread and salt in the traditional fashion. Later, they carried unspecified loads from the Soyuz ferry into Salyut 6, and began mothballing the Soyuz. Letters and telegrams were handed over to Kovalyonok and Ivanchenkov.

The new crew were to stay onboard the Salyut for seven days, before returning to Earth, leaving Kovalyonok and Ivanchenkov to continue their programme. During their seven days, the Soyuz 30 crew would study the manufacture of semi-conductors in space, carry our bio-medical examinations on the effects of space flight on the human organism, photograph the Earth, and do technical experiments on the function of individual systems of the complete space complex.

Novosti reported that UN Secretary-General Kurt Waldheim had sent a message of greetings stressing that the mission was "another important stride in the international

efforts towards the peaceful exploration and utilization of space."

Vladimir Shatalov said in an interview that there was no rush to send representatives of each Intercosmos country into space as soon as possible. Each mission reflected, to some extent, the particular scientific interest of the country involved – in Poland's case, space technology, space ergonomics and psychology, and a series of medical experiments.

The two Polish cosmonauts, Hermaszewski and Jankowski, had, he said, both displayed "splendid knowledge of the techniques and sound know-how in the handling of spacecraft." Once they had completed the unloading of Soyuz 30, the two crews rested from 23.30 until 08.00 on 29 June. After breakfast, and a check of the complex systems, the crew started on their work programme.

The Soyuz 30 crew examined their blood circulation with the Polynom-2M apparatus, a rheograph, and a "Beta" instrument. In addition, they performed physical exercises, photography, filming, and television reporting.

In a communications session, Kovalyonok promised Brezhnev and Guerik that the cosmonauts would fully carry out their programme. Klimuk said: "Our day has been strenuous, because on the first day of adaptation to weightlessness our sense of well-being has to improve, but work must not suffer. Today we were engaged on medical and biological research and checked on the filling with blood of the vessels of the brain and various parts of the body. Then we conducted technological experiments. Apart from that it was necessary to transfer all the equipment which Soyuz 30 had brought to the Salyut 6 orbiting station."

Sirena Experiment

The day's programme included the start of the Soviet-Polish "Sirena 1" experiment with the Splav furnace. The 46-hour experiment began in the evening, and involved Hermaszewski placing ampoules containing mercury, cadmium and tellurium in the Splav.

The resulting crystal semi-conductor would be one of the most sensitive known detectors of infrared radiation. It could be used for astronomical research, even when the skies are clouded, or when dust and other pollution are present. It could also be used for "super-accurate photography of the Earth's surface" from orbiting stations such as Salyut 6. Such crystals were also said to be essential for ensuring the further development of laser technology, as many lasers operate on IR radiation principles.

A Polish Press Agency report carried details of the experiments prepared for the Soyuz 30 flight. There were five from Poland, and six prepared jointly by the Soviet Union and Poland, Czechoslovakia and the GDR.

The five Polish experiments were:

- *Sirena:* Materials Processing.
- *Smak* (Taste): Designed to measure taste sensations in weightlessness. (Polish = Vkus) (see 30 June).
- *Relaks* (Relax): Designed to determine the influence of recreation exercises upon the psychological condition of the crew during a lengthy space flight.
- *Kardiolider* (Cardioleader): Designed to control the physical effort of a cosmonaut by monitoring the cardiac strain involved and warning of excessive strain by means of a device designed and constructed in Poland.
- *Zdrowie* (Health): Designed to estimate the physical capacity of a cosmonaut before the start of a mission, and upon landing, by means of equipment designed and constructed in Poland. The device makes it possible to estimate physical efficiency through simultaneous ECG analysis, analysis of the rate of cardiac contractions, automatic control of blood pressure, respiration rate, the volume of lung minute ventilation, and the so-called deep temperature of the body.

The experiments were prepared by various Polish research centres and institutes including the Physics Institute of the Polish Academy of Sciences, the Institute of Aviation Medicine, and the Institute of Geodesy and Cartography. The work was co-ordinated by the Space Research Committee, chaired by Academician J. Rychlewski.

On 30 June, the Soyuz 30 crew underwent medical tests, and these showed the pulse rates of Klimuk and Hermaszewski to be 75 and 55 respectively, with blood pressures of 120/70 and 125/60. Using the Chibis suit and Polynom-2M equipment, they carried out investigations into the reaction of the cardiovascular system to hydro-static pressure.

All four cosmonauts participated in the "Smak," or "Vkus" (Taste) experiment, designed by the Polish Military Institute of Aviation Medicine to discover why the sense of taste changes in conditions of weightlessness. According to Radio Warsaw, "some foods which were once consumed with delight, taste suddenly like sawdust and ashes, while other foods assume sensationally attractive tastes." A unique instrument, an "electrogustometer" or "electrotaste meter" was being used in the experiment. The method of measurement basically involved electrical stimulation of taste buds, which enabled the cosmonaut to measure his taste sensations under weightlessness. The method was said to give accurate and fast results, and to be easy in application.

Press Conference

A highlight of the day's activity was a Press conference during which the four cosmonauts spoke to reporters at MCC. Hermaszewski revealed that "we have with us a casule of soil taken from the Byellorussian village of Lenino and from near Warsaw. This soil has been made sacred by the blood of Soviet and Polish soldiers. With this capsule there is a medal dedicated to the flight of the first Pole in space. Were it not for this soil and our friendship, there would be no space event today, or today's festivities on Polish soil."

Speaking of future cosmonauts from other Socialist countries, Hermaszewski said: "We have known many of them for a long time, and have worked with colleagues from the GDR, and got to know our friends in this field from Bulgaria, Hungary, Cuba, Mongolia and Roumania. Above all, we wish them good health, which will never come amiss in our hard job. We assure you that this house is a good one and the working atmosphere is splendid."

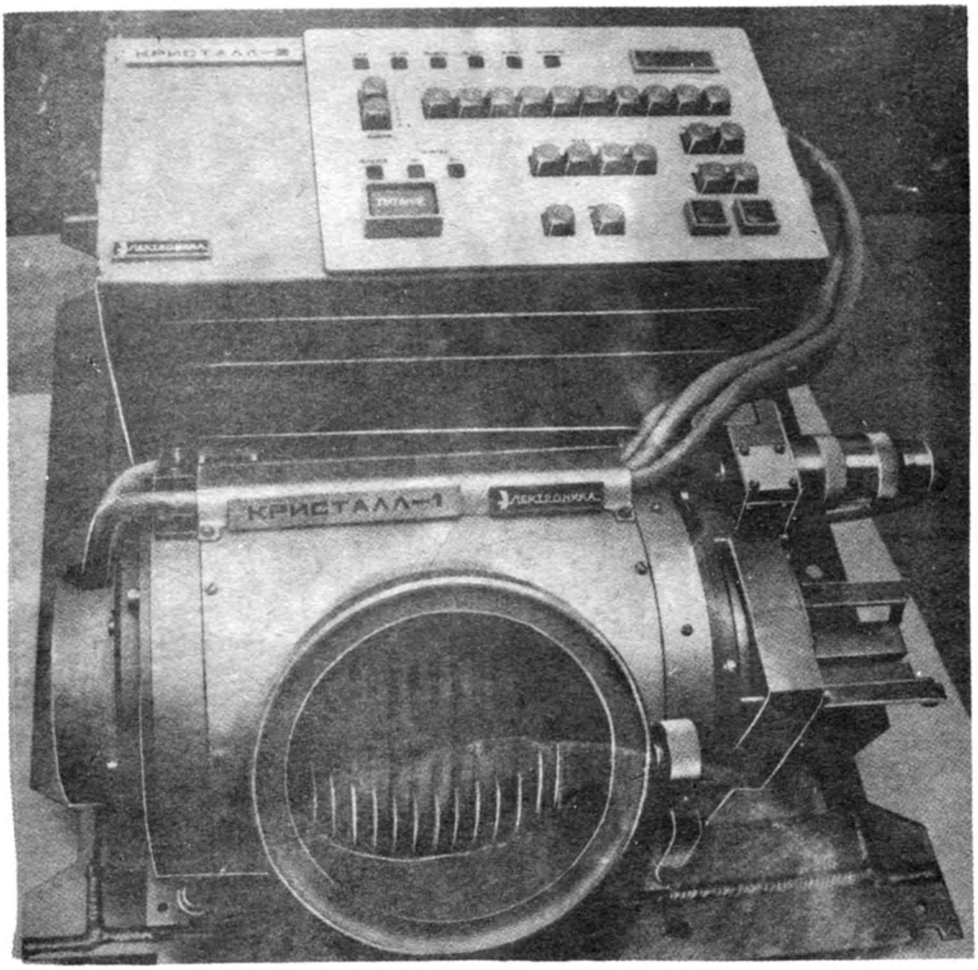
On 1 July, Kovalyonok and Ivanchenkov had a day of active rest. They conducted medical tests and both cosmonauts said they felt well. Kovalyonok's weight had stabilized, but Ivanchenkov had lost a little. Each man's appetite was good, and both were sleeping well. All four men were said to be in high spirits, with "much laughing and joking going on."

Klimuk and Hermaszewski completed the Sirena-1 experiment, and conducted medical experiments. One of the latter was a heat exchange experiment, in which the cosmonauts subjective impressions of thermal comfort were compared with instrument readings. The two men also conducted tests of the Kardiolider (Cardioleader), to control their energy spendings during the flight. The Polish designed experiment aimed at a controlled programme of exercise in which the effort spent in physical exercise was proportional to the action of the heart of the man using the given piece of equipment.

A miniature electronic sensor employed in the experiment was constructed by specialists from the Warsaw Institute of

Ampoules used in the Beronlina technology experiment carried out by Sigmund Jähn and Valery Bykovsky on board Salyut 6. Picture shows the Kristall furnace. Inscription inside the case reads: "Intercosmos Experiment Beronlina, USSR-GDR Apparatus Splav-01."

Photos: Panorama DDR/Zentralbild



The Kristall space furnace as shown at the Kalinin Flight Control Centre north-west of Moscow at the beginning of September 1978. (The Splav 01 furnace was illustrated in *Spaceflight*, February 1979, p. 56).

Air Medicine. Its three electrodes are placed on the cosmonaut's chest to monitor the currents of his heart, while another lead links the machine to the running track, or bicycle-ergometer.

Klimuk and Hermaszewski used the bicycle-ergometer during their experiments, and, according to Dr. Yegorov, a detailed examination of the two mens' cardiovascular systems had not disclosed any dangerous symptoms. Changes characteristic of adaptation to weightlessness "did not go beyond the acceptable limits." As well as measuring physical exercise, the Kardiolider was said to be of particular value in measuring how well readaptation to Earth gravitation was proceeding, following their return to Earth.

An article in *Pravda* reported that Hermaszewski had with him onboard Salyut 6 a fragment of a facsimile edition of the Great Polish astronomer Kopernicus's "On the rotations of the Heavenly Spheres" and a reproduction of a sketch of the Solar System taken from the book.

On 2 July, a Moscow Press conference was told that thanks to the introduction of Progress Tankers, Salyut 6 could now remain operational for up to five years. Previous Soviet estimates had placed the lifetime of a Salyut at between two and two and a half years; so, in effect, they were now saying that Progress Tankers had doubled the useful life of Salyut stations.

Radio Moscow reported that Salyut 6 was making 16-17 revolutions every 24 hours, covering 600,000-700,000 km (372,840-434,980 miles). During the day, the cosmonauts observed and photographed the Earth using the MKF-6M and the BST-1M sub-millimetre telescope. They took pictures of the Aurora Borealis and then oriented the station before taking photos of regions of the European part of the Soviet Union, Kazakhstan and the oceans.

They also carried out an experiment code-named "Ziemia" (Earth), involving the photography of selected areas of Southern Poland. The same areas were to be photographed from different altitudes with the help of aircraft, and the data was to be subsequently compared and analysed.

Radio Warsaw reported that Salyut 6 had flown over Poland at 16.48 and 18.20, continuing the "Ziemia" experiment: Work on this would be continued the next day.

On 3 July, the parameters of the Salyut complex were 360 x 336 km (224 x 209 miles) x 91.2 min x 51.6°. In the morning, the cosmonauts had a medical check-up, and all four had normal blood pressure and pulse rates. They continued photographing the Earth. In the afternoon, they carried out the Sirena-2 experiment, due to last 14 hours, in which tellurium, cadmium and mercury were smelted. The resulting semi-conductor material should be worth at least $8,000 per gram, according to Radio Moscow.

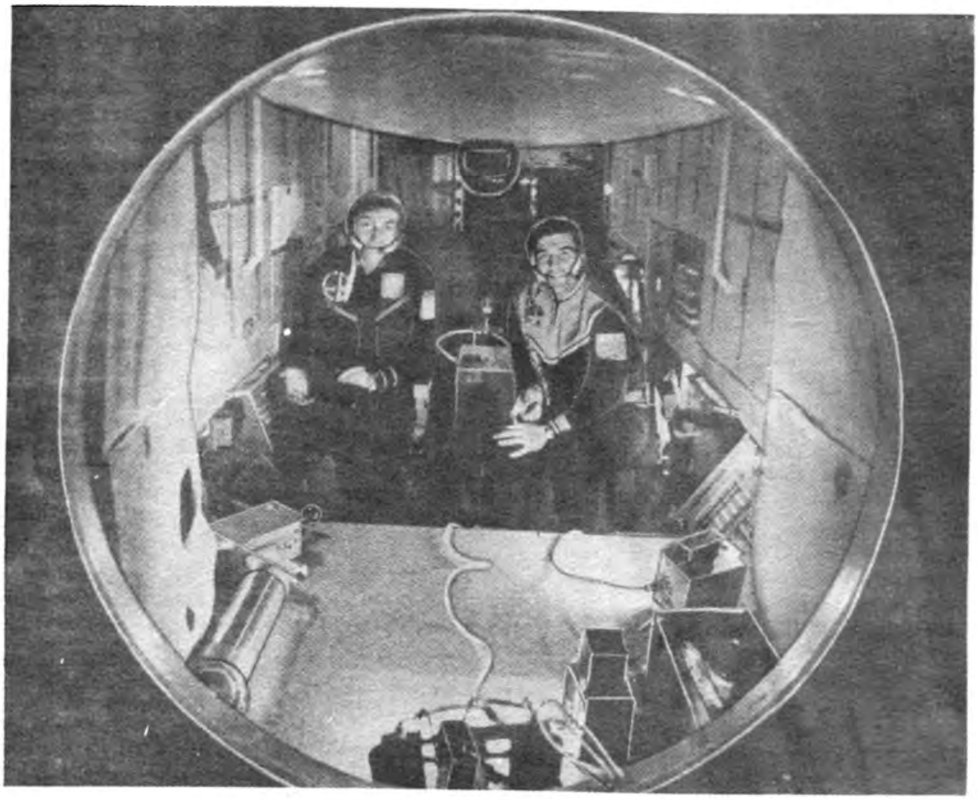
Although space processing was a key area of the Salyut 6 mission, some Western observers predicted that the Soviets would perform welding, soldering, and cutting on future missions, and that some experiments in this area might be possible during the current flight. Such research activities are related to the building of large structures in space.

The cosmonauts also carried out the Polish psychological experiment, "Relaks" (Relax) to determine the most favourable conditions for rest in orbit. It involved the study of stresses and how to reduce them, keeping the cosmonauts mentally fresh during protracted flights.

Various relaxation programmes were drawn up in conjunction with the cosmonauts, and also without their participation. For example, Hermaszewski's idea of relaxation during work days onboard Salyut 6 included listening to music by Chopin, Polish operatic music, and watching a video recording of a cabaret. The psychologists supplemented the cosmonauts personal tastes with a lot of ideas of their own, with an emphasis on "who-done-its" and childrens' cartoons.

In another psychological experiment, the cosmonauts kept notes on the work routines which gradually became less difficult to perform as the flight progressed. They also had to note the things which irritated them, what troubles caused by zero-g affected them, and how the relationships between the four men fared as time passed in their fairly cramped conditions.

On 4 July, Klimuk and Hermaszewski were busy transferring research materials, flight documents and mail to Soyuz



The international crew of Soyuz 30 during training: Pilot-Cosmonaut Col. Pyotr Ilyich Klimuk (right) and the Polish cosmonaut-researcher, Major Miroslaw Hermaszewski.

Tass

Picture received by television from Salyut 6 at the time when Soyuz 29 and Soyuz 30 were docked with the space station. Photo shows Kovalyonok, Ivanchenkov, Klimuk and Hermaszewski.

Novosti Press Agency

30. All four cosmonauts indulged in a little ceremony, signing a sealed letter certifying that the "second international crew made a flight in Soyuz 30, had linked with the Salyut 6 and Soyuz 29 and transferred to the station."

During the subsequent communications session, Klimuk and Hermaszewski reported that they had successfully completed the programme of scientific research and experiments. Hermaszewski remarked what a pity that it was already time to return.

Soyuz 30 Returns

On 5 July, at 10,15, Soyuz 30 undocked from Salyut 6 as the station was flying just to the north of Khabarovsk. The landing programme onboard Soyuz 30 was switched on at 11.39, according to Radio Warsaw. The capsule's parachute could be seen from the ground at 13.19.

The descent module touched down at 13.31 in the predetermined area on a maize field on the Rostov state farm, some 300 km (186 miles) west of Tselinograd. Pyotr Klimuk was the first to emerge, in accordance with regulations. The mission had lasted seven days 22 hours and 04 minutes.

Local farmers soon arrived at the landing site, and presented the cosmonauts with huge bouquets of flowers together with bread and salt. Asked if he was alright, Hermaszewski replied: "Of course I'm alright. I feel well. Naturally, I am a little dizzy and my knees are rather wobbly."

When reporters interviewed Pyotr Klimuk, he said: "We're very pleased indeed and very glad to be back, although we do feel a bit top-heavy. It's difficult to stand on one's feet, even though the flight was a short one. The whole programme has been carried out and after the material is worked over, we hope the scientists will get some interesting data. Miroslaw and I have been thinking all the time about our colleagues we left behind us in the orbital station, Vladimir Kovalyonok and Alexander Ivanchenkov. As the hosts at the station, they helped a great deal in carrying out the flight programme. Their programme was more complex than ours."

Hermaszewski then spoke, and his message was broadcast straight to Poland, so an interpreter was on hand to translate what he said into Russian for audiences in the Soviet Union. Hermaszewski said that he felt fine, "although during the first minute after being back on Earth, we both still had the effects, or we felt the effects, of weightlessness. For example, I was surprised to find that my watch was so heavy. The doctors say that this feeling will pass soon. The first check has shown that our condition is good; tomorrow it will be still better.... We landed on a wonderful maize field. Standing around us were smiling people. I has a very pleasant sensation on landing," he concluded.

The two cosmonauts were flown back to Tyuratam/Leninsk, and soon afterwards appeared at a Press conference. Asked how he felt, Hermaszewski said:"We are both feeling just fine, but the first moments back in contact with the Earth are rather specific in character. You rather lose your sense of balance, your legs don't work as they ought to. I lifted my microphone and thought someone had put a bit of lead inside. I even feel the weight of my writswatch still. The doctors say we're in good trim, and the various functions they have checked are within accepted standards. I think we'll be alright tomorrow. But the thing that gave me the greatest satisfaction, was that field of maize before we landed; beautiful, lush green maize. It was difficult to say goodbye to the two men who are still up there in the space station, and I wished them the very best."

Describing the re-entry and landing, Hermaszewski said. "The landing was very dynamic, beautiful and fascinating. You sit in the landing capsule and you see nothing but flames all around, but you know nothing is going to happen to you, and that you must take it all in, watch everything that happens, be sure to remember it later. It's beautiful and frightening at the same time, and there is a little doubt uncertainty. You trust the machines, you trust the technology, but in your heart of hearts you may still have that nagging doubt."

The two cosmonauts had brought back to Earth with them the results of their experiments, including semiconductor materials, micro-organisms cultivated in zero-g, and photos of the Earth and the oceans. Radio Warsaw reported that 12 Polish experiments had been carried out – nine in space medicine, and one each in physics, geophysics and'tele-detection'.

Both men were promoted following the successful conclusion of their mission, and Hermaszewski was made a Hero of the Soviet Union. Klimuk, already twice a Hero of the Soviet Union, was awarded the Order of Lenin. Both men were also decorated by the Polish State Council.

On 6 July Kovalyonok and Ivenchenkov conducted medical experiments, while back on Earth, Klimuk and Hermaszewski attended a ceremony in Moscow. Leonid Brezhnev warmly congratulated the two men on their flight, and presented them with their awards. "Your flight," he said, "required limitless courage and a strong will. It's a matter of specific pride that a fellow countryman of the great Polish astronomer Nikolas Kopernicus has now been on a space flight."

"Every year," he continued, "richer and richer fruits are forthcoming from the joint efforts by the countries of the Socialist community in affairs on Earth and now in outer space. The joint work of our cosmonauts is getting brilliant results, enriching mankind with new knowledge and discoveries. There will be more launchings in which citizens of other Socialist countries will take part. Today we pay tribute to Pyotr Klimuk and Miroslaw Hermaszewski for the completion of their space flight, and for the courage and heroism displayed during it."

A Polish Press Agency report quoted Hermaszewski as saying it was a pity that in the past two to three days the cosmonauts "had not managed to fully implement the programme of taking photographs of Polish territory. The only cause for this was bad weather conditions. However programme Ziemia ("Earth") will be continued."

On 7 July, another automatic supply craft, Progress 2 was launched.

[Continued on page 138

SPACE REPORT

A regular monthly review of Space Events and Technical Trends

VENUS PROBES ALTER PLANETARY THEORIES

Theories about the origin of the Solar System's inner planets are being hastily revised as a result of the U.S. planetary assault on Venus by six Pioneer spacecraft last December, writes USICA Science Correspondent, Everly Driscoll. One of the spacecraft endured the corrosive, sulphuric-like atmosphere to survive on the 480-deg C (900-deg F) surface for an hour and seven minutes, although the craft was not designed to report from the surface.

Data sent to Earth from the five entry probes and the one Orbiter are most unexpected.

The most surprising tentative find – after an early look at the data – is that Venus, compared with Earth, appears to have much more primordial gas (argon 36) left over in its atmosphere from 4,500 million years ago when the planets formed out of the gas and dust circling the newly-born star, the Sun.

How Venus could have more argon than Earth – and much more than Mars – is baffling scientists gathered at the Ames Research Center in California where the Pioneer Venus data are processed.

Theoretically, the inner planets – Mercury, Venus, Earth and Mars – should have lost most of their primitive gas long ago and there is no readily available explanation as to why Venus should have retained its primordial atmosphere while Earth apparently lost its primitive material, since both planets are about the same size and distance from the Sun.

"Our ideas of planetary formation have had to be simplistic," explains Pioneer scientist Michael B. McElroy of Harvard University, "because, until a few years ago, Earth was the only planet we knew. We tried theoretically to build Mercury, Venus and Mars our of the same elements as Earth."

Said Dr. Thomas Donahue of the University of Michigan: "it's back to the drawing boards, creating new theories of planetary formation and evolution."

The four Pioneer spacecraft that descended to the surface found the expected amounts of oxygen, carbon, nitrogen, helium and neon as well as water vapour in the Venurian atmosphere. The mother-craft or 'bus' that carried the four smaller spacecraft also sent data for four minutes from Venus before being burned up on entry to the atmosphere (the bus, unlike the four landed probes, had no heat shield). The sixth spacecraft, an Orbiter, arrived at the planet on 4 December and will continue mapping both the atmosphere and the surface (with radar) for one Venurian year – 225 Earth days.

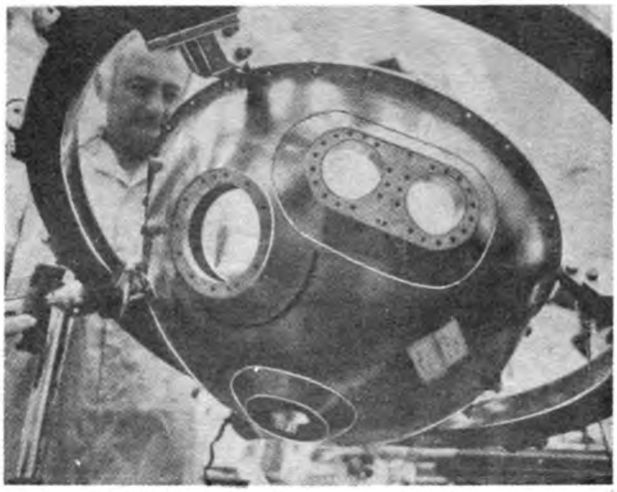
The six-spacecraft mission unfolded precisely, each probe arriving and entering the Venurian atmosphere within seconds of the timeline and crash-landing on the surface on time.

"It was the most difficult job of tracking and communication we have ever attempted," said Pioneer manager Dr. Charles Hall of Ames. Earth's tracking stations had to keep up with six spacecraft simultaneously, each sending hundreds of bits of information.

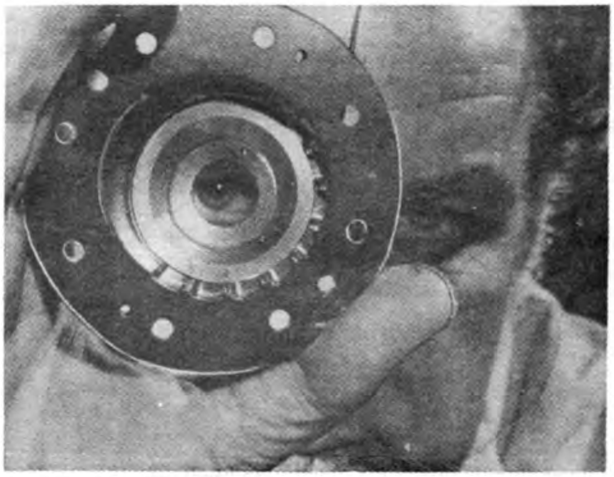
As the four spacecraft that landed plunged into the thick Venurian atmosphere, each experienced communications blackout. But each reinitiated radio communications precisely on time after entry. The spacecraft transmitted temperatures, pressures and composition of the air and cloud decks.

Below 49 km, "the atmosphere is remarkably clear all the way to the surface," says Dr. Boris Ragent of Ames.

At 15 km above the surface, all four probes recorded temperatures of 710 deg F (377 deg C) and all experienced



An engineer at Hughes Aircraft Company in Segundo, California, checks out one part of a probe sent to Venus aboard Pioneer Venus 2. The item is part of a pressure vessel, made of titanium to protect delicate scientific instruments from Venus' acid-laden clouds, surface temperature above 480 deg C and pressure equivalent to 3,000 ft (914 metres) beneath the Earth's oceans.



This 13.5 carat diamond was aboard one of the multi-probes which entered the atmosphere of Venus on 9 December. Three windows in the wall of the probe were sapphire, but a diamond was essential to admit light for measurement by an IR radiometer.

Hughes Aircraft Company

a problem, perhaps caused by an electrical short circuit brought on by the corrosive atmosphere; the transmission of probe temperature data became erratic. "We don't yet understand what happened," says Dr. Alvin Seiff of Ames. The probes continued to send other data all the way to the surface, and the one probe for 67 minutes on the surface.

The Soviet's Venera 8 that landed on Venus reported for 107 minutes from the surface and measured surface temperatures of 900 deg F (480 deg C) and pressures more than 90 times the atmospheric pressure at Earth's surface.

Those data are consistent with U.S. Earth-based studies indicating Venus is a most inhospitable, seething planet, where a run-away greenhouse effect has occurred. The carbon dioxide and water vapour in the atmosphere trap solar heat, preventing its escape to space, heating the surface to temperatures high enough to melt lead and zinc.

The Pioneer Orbiter, circling the planet while the probes travelled to the surface, measured temperatures at the north pole 40 degrees hotter than temperatures at the equator where most of the Sun's light falls. Scientists speculate that the equator-to-pole circulation of the atmosphere causes these differences. Venurian hot air rises at the equator, cools as it flows toward the poles. At the poles the air plunges downward and is heated in transit by compressional forces.

The Venurian scientists – including international scientists such as Dr. Jacques Blamont of the University of Paris and Dr. Ulf von Zahn of the University of Bonn – will continue analyzing the Pioneer data for months.

The scientists hope to answer fundamental questions: "What makes Venus so different from Earth?" and "could a build-up of carbon dioxide in Earth's atmosphere from fossil fuel consumption create a similar greenhouse effect with seething surface temperatures on Earth?"

1984 VENUS PROBE

NASA is asking scientists to propose experiments for a 1984 planetary mission designed to provide the first global view of the surface of Venus. Launched by the Space Shuttle, the Venus Orbiting Imaging Radar (VOIR) spacecraft would circle the planet for at least seven months, taking radar pictures and making measurements of the atmosphere as well as the surface. It would be the most detailed scientific examination ever made on the surface of that planet, which is perpetually covered by clouds.

The spacecraft itself, weighing approximately 5,000 kg (11,000 lb) at launch, will consist of a bus with a Synthetic Aperture Radar (SAR) and other science instruments.

In announcing the solicitation for scientific investigations, Dr. Noel W. Hinners, NASA's Associate Administrator for Space Science, said: "NASA is engaged in a continuing programme of space exploration, a major part of which is directed at the Solar System. The VOIR programme is a key step in that endeavour.

"While considerable knowledge of Venus' atmospheric properties will be forthcoming from the Pioneer Venus mission, and while the Soviet Venera missions have provided valuable data on surface properties at three localities, information regarding the surface morphology on a global scale – and all of the insights that this scientific information provides – is lacking. A major technical goal of the VOIR mission therefore is to obtain global radar imagery with sufficient resolution to address fundamental questions regarding the origin and evolution of the planet, and to lay the groundwork for subsequent, more detailed investigations of the surface and interior."

Dr. Hinners said VOIR can also address itself to a number of problems that were not studied – or were incompletely studied – by the Pioneer Venus mission.

Hinners emphasised that VOIR has not been approved, but said that early selection of scientific participants and investigations allows for advanced studies to assure a well-defined programme when approval is received.

According to plans, NASA would launch one spacecraft from the Shuttle to Venus in 1984. A typical trajectory would begin in December 1984 and provide for arrival at Venus in May 1985. The spacecraft would then be inserted into an elliptical parking orbit, where it would remain throughout May and June 1985 while the NASA Deep Space Network was occupied with the Galileo project (a 1984 deep probe mission to Jupiter). In late June or early July, a propulsion manoeuvre would place VOIR into a near-polar orbit at an altitude of 300 km (180 miles).

Radar mapping and other science gathering would begin in July and continue for five months.

The mapping activity would result in near-global coverage of the planet in moderate resolution (about 1 km – 0.6 mile) imagery, and coverage of a small percentage of the planet's surface in higher (about 100 km – 60 miles) resolution pictures.

Venus has yielded her secrets with great reluctance, principally because of the obscuring clouds, crushing atmospheric pressure (100 times that of Earth) and searing temperatures (480 deg Celsius or 900 deg Fahrenheit). Several probes, both American and Soviet, have penetrated the planet's atmosphere and transmitted important data for periods ranging from minutes to hours. But none has provided a satisfactory picture of the planet's surface overall.

The VOIR imagery is expected to disclose the presence or absence of continents, ocean basins, mountain belts, rift valleys, fault belts or volcanoes. The nature and time sequence of plate tectonic activity (continental drift) may also be revealed, as well as any relationship between this and volcanic episodes in the history of the planet.

If impact craters are present, as suggested by Earth-based radar observations, their size and frequency can be determined.

Other science investigations will be conducted which relate to the planet's fundamental geophysical and atmospheric problems.

GLOBAL CROP SURVEY

A three-year Large Area Crop Inventory Experiment (LACIE) using space age technology to monitor global wheat production has been completed. The results were presented at a symposium at the Johnson Space Center, Houston, Texas, attended by more than 700 conferees from 22 nations representing federal agencies, private companies, universities and the governments of foreign countries.

The experiment was begun in 1974 to determine if data from the Landsat satellite, orbiting some 805 km (500 miles) above the Earth, could be used with surface weather observations and information derived from U.S. operational environmental satellites to predict production of the world's most important grain crop – wheat.

The major foreign study areas were Canada and the Soviet Union, with preliminary examination of wheat-growing areas of Australia, the People's Republic of China, Brazil, India and Argentina. The U.S. Great Plains was used extensively to test and evaluate the several techniques since it was the best source of statistical data with a known reliability.

The LACIE techniques were intended to enhance the accuracy of existing global wheat production forecasts by improving foreign production forecasts and to do so as early in the crop season as possible. The accuracy goal set by the project was to develop a system which would provide estimates accurate within 10 per cent of the true production at harvest in nine years out of 10.

In tests over the winter wheat area of the Great Plains it was determined that the accuracy goal could be met. When the techniques were used to monitor the Soviet wheat crop harvested in 1977, the LACIE produced a production estimate of 91.4 million metric tons, less than one per cent below the official mark of 92.0 million tons released by the Soviets. However, the capability to achieve such accuracy from year to year has yet to be demonstrated.

The findings were presented to the four-day October symposium by the LACIE participants: NASA, the Department of Agriculture (USDA), the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce and cooperating universities and industry.

In other study areas such as the spring wheat regions of the U.S. and Canada where long narrow fields are hard to distinguish and where wheat can easily be confused with

other spring-planted crops, the accuracy goal was not met. Most importantly, however, LACIE was able to determine the reasons for not meeting its goal in these areas and to identify what would be needed to do so. Future satellites with improved resolution should allow smaller fields to be identified with accuracies similar to that encountered in the Soviet Union where fields are typically quite large.

An evaluation team composed of prominent scientists and chaired by Dr. Don Paarlberg, former Director of Economics for USDA, reviewed the LACIE techniques and presented their report at the symposium. In the report, Dr. Paarlberg stated that, "LACIE results to date clearly demonstrate that present remote-sensing capabilities can be combined with or substituted for conventional methods of information collection in order to improve foreign crop production estimates." He concluded the evaluation of the results by saying, "... for global wheat regions such as the USSR the LACIE technology can be made operational and that for regions where the technology requires improvment, funding for further research and development should be continued."

NASA, USDA and NOAA which collectively provided the many different skills necessary to make LACIE a success are now defining a follow-on activity to extend the application of space-age technology to agriculture. USDA has established an office in Houston near the space centre to test the usefulness of LACIE technology in crop condition assessments.

Similar to space exploration done before, the LACIE experiment provided other benefits, notably, in the area of meteorological research.

NOAA scientists used the techniques they developed to relate crop yields to weather and devised mathematical relationships for relating temperature to home heating fuel consumption. These relationships have been used in conjunction with extended forecasts during the past two years for projecting areas of the country where consumption would likely be higher or lower than normal and, thus, allocating the additional amounts of fuel needed in a better manner. This capability which has evolved represents a new national ability to assess the impact of climatic fluctuations and will be extended to other critical national resources.

NASA EXTERNAL RELATIONS

Arnold W. Frutkin has been apppinted NASA Associate Administrator for External Relations. Since 2 March 1978 he had served as Deputy Associate Administrator for External Relations, and, since 4 June, as Acting Associate Administrator. Previously,he headed NASA's Office of International Affairs for 18 years.

In his new position, he is responsible to the Administrator for the development of external policy and the coordination of NASA activities dealing with the public, the international community, universities, state and local governments and the Department of Defense and other federal agencies.

SEASAT MISSION ENDS

After nearly a month of attempts to reestablish contact with Seasat, NASA's experimental oceanographic satellite, project officials declared the mission formally terminated. Data collected during the spacecraft's 106-day lifetime are being processed at NASA's Jet Propulsion Laboratory, Pasadena, California. Project officials expect the task to occupy more than one and a half years.

Seasat's synthetic aperture radar completed some 300 data-gathering passes during which it collected about 60 hours of data including images of sea ice, waves, coastal conditions and various land forms (see *Spaceflight*, January 1979, page 30). The spacecraft's scatterometer (sea surface wind speeds) and scanning multi-frequency microwave radiometer (sea surface temperature and wind speed) collected data for 99 days. Seasat's altimeter and visual and infrared radiometer returned data for 70 and 52 days respectively. In addition, a series of sea surface, fact-finding experiments conducted with Seasat were completed.

Objectives of the Seasat programme, a proof-of-concept mission, were threefold:

- To demonstrate techniques to monitor the Earth's oceanographic phenomena and features from space on a global scale;
- To provide oceanographic data in a timely fashion to scientists who study marine phenomena and to those users who regard the oceans as a resource, namely, ocean shippers, fishermen, marine geologists etc.; and
- To determine the key features of an operational (full-time) ocean monitoring system.

Analysis of the Seasat-collected data by teams of scientists, engineers and user representatives indicates the first of the above objectives will be largely met and a high probability of accomplishing the major part of each of the latter two objectives. A failure review board is working to determine the causes of the premature end to the spacecraft's operation.

Seasat was launched on 26 June 1978, from Vandenberg Air Force Base, California, and contact was lost with the satellite on its 1,502nd orbit of Earth on 9 October 1978, when a so-far unexplained short circuit drained all power from the batteries.

EUROPE CONTROLS U.S. SATELLITE

A remarkable example of international space collaboration, in which the European Space Agency plays a major role, is illustrated by the network of satellites which has been established in the field of Earth observation and meteorology.

In addition to building the highly successful Meteosat, which has been operating for more than a year in Clarke orbit 35,880 km above the equatorial Atlantic, on 1 November last ESA took over responsibility for operating the American GOES-I ('I' stands for Indian Ocean) meteorological satellite of the National Oceanographic and Atmospheric Administration (NOAA) as part of the first Global Atmospheric Research Programme (GARP) experiment of the World Meteorological Organisation (WMO). The occasion was marked on 14 November 1978 by a ceremony at the ESA ground station at Villafrance del Castillo, near Madrid, which will receive the satellite data.

This first GARP worldwide experiment – which will last a year, from 1 December 1978 to the end of November 1979 – aims at improving the understanding of the energetic process of the atmosphere and the methods for forecasting the evolution of the general atmospheric circulation. It is based on a multiple observation technique, and mainly on a worldwide network of five geostationary meterological satellites regularly distributed around the Earth which will simultaneously provide an overall picture of the cloud coverage.

This network initially foresaw the use of:

- two American satellites of GOES (Geostationary Operational Environmental Satellite) type from NOAA;

- one Japanese satellite: GMS (Geostationary Meteorological Satellite), launched on 14 July 1977;

- one European satellite: Meteosat – from ESA – launched on 24 November 1977;

- one Soviet satellite: GOMS (Geostationary Operational Meteorological Sputnik).

In late 1977, the Soviet Union having announced that it would not be able to place the GOMS satellite in orbit for the first GARP experiment, the WMO requested the United States and ESA to study and implement a contingency plan to avoid any discontinuity in the observation network.

The solution adopted was proposed jointly by NOAA and ESA. It consists in shifting the American GOES-I satellite, already in orbit, from 135° West to 60° East, i.e., to a position above the Indian Ocean – virtually the same position between the European satellite Meteosat and the Japanese GMS satellite that was originally to have been occupied by the Soviet GOMS spacecraft. All the operational responsibilities (positioning and station keeping, control, disseminating and archiving image data) have been transferred to ESA.

GOES-I – which reached its final station in late November – is being controlled by the European Space Operations Centre (ESOC) at Darmstadt, Germany with the aid of the Villafranca del Castillo ground station in Spain, which has been supplied for this purpose with equipment from the United States (including a 13 m diameter antenna) and ESA.

This station will be responsible for the acquisition and archiving of the image data which will be processed primarily by the University of Wisconsin in the United States. Complementary processing will be performed in Europe by the Deutsche Forschungs-und Versuchsanstalt für Luft-und Raumfahrt (DFVLR) in Germany and by the Laboratoire de Météorologie Dynamique (LMD) in France. In addition, the Villafrance station will retransmit the stretched image data to the satellite for dissemination to the GOES data Users' Stations. To enable the Meteosat Data Users' Stations to acquire these data, the Centre de Météorologie Spatiale (CMS) at Lannion (France), which already relays the GOES-E image data, will also receive the GOES 1 stretched image data, reformat them in WEFAX and disseminate them *via* Meteosat.

Thus it has become possible within the Meteosat telecommunications coverage to receive Earth images – in the visible and infrared bands – from three geostationary satellites, GOES-E, Meteosat and GOES-I, covering about two-thirds of the globe.

METALLIC XENON

American scientists – by applying tremendous pressure – have, for the first time, made xenon, the rarest of the stable rare gases, into a metal.

David A. Nelson, Jr., and Professor Arthur L. Ruoff, of the Department of Materials Science and Engineering, in work sponsored by NASA's Lewis Research Center, Cleveland, Ohio, reported pressures of 320,000 atmospheres applied to solid xenon at -241 degrees Celsius (-402 degrees Fahrenheit) produced this new material.

Xenon when frozen solid does not conduct electricity. But at the pressures applied in the Cornell experiment the electrical conductivity of the solid xenon increased more than a 100,000 million times; that is, it behaved as a metal. Only a very tiny amount of xenon was used in the experiment.

The enormity of the pressure used becomes apparent when it is noted that the pressure in the deepest part of the ocean, about 11 kilometres (35,000 ft) down, is only about 1,000 atmospheres. The pressure was six times that used to produce synthetic diamonds.

Because xenon returns to the insulating (non-conductive) state when the pressure is removed, no engineering applications are apparent. However, Ruoff noted, "The production of metallic xenon is of considerable scientific interest. Furthermore, the development of these techniques is a step forward in high pressure research." Ruoff believes that his group now has the capability of making oxygen and krypton metallic as well as possibly nitrogen, argon and even hydrogen.

Ruoff notes that theorists have predicted that hydrogen and even diamond itself will become metallic at high enough pressures, perhaps several million atmospheres.

If frozen hydrogen could ever be made metallic and remain in that state when the pressure is removed, it might have such practical uses as an extremely powerful rocket propellant, a semiconductor or an improved source for fusion energy. NASA is exploring the possibility of making metallic hydrogen.

To produce metallic hydrogen, much smaller pressure tips and tinier electrodes will be needed. Ruoff and associates are working on electrodes with widths and spacing of only one-hundred-thousands of an inch.

Small quantities of metallic hydrogen were reported to have been produced in the Soviet Union some two years ago. Ed. (See 'Spaceflight', May 1977, p. 175).

PAYLOAD ASSIST MODULE

McDonnell Douglas Corporation has received the first order for its new Payload Assist Module (PAM), a privately developed rocket vehicle that can operate from the cargo bay of the U.S. Space Shuttle or as the upper stage of a conventional Delta booster.

The order, worth more than $16 million, was placed by Hughes Aircraft Company's Space and Communications Group and covers six PAM's. They will be used in the 1980's to propel spacecraft built by Hughes into high-altitude geosynchronous transfer orbits after being launched to low-altitude orbits aboard the Shuttle or by Delta.

McDonnell Douglas Astronautics Company at Huntingdon Beach, California, is developing the PAM with company funds as a commercial space vehicle system to support commercial, Government and international satellite operators in the transition from expendable launch vehicles to the reusable Space Shuttle.

Communications satellites and other spacecraft aimed toward geosynchronous orbits at 22,300 ml (35,887 km) must be transferred upward from the Shuttle with a boost from another rocket. The PAM provides that energy and gives operators the option of using either the Shuttle or a Delta.

The PAM will be able to place up to 2,320 lb (1,058 kg) of payload into a geosynchronous orbit with either a Delta or Shuttle launch. Options are available, on Shuttle launches only, to raise this capability to 2,750 lb (1,245 kg).

The PAM will be powered by a solid-propellant rocket motor designated Star 48, being developed by the Thiokol Corporation under an MDAC contract. The motor will be 48 in (122 cm) in diameter and approximately 6 ft (1.83 m) long. Variations in propellant loading and in the rocket nozzle length are available to tailor the system for specific

mission requirements.

A payload attach fitting at the top of the Star 48 motor joins the PAM to the spacecraft. At the base of the motor there is a spin table and separation system similar to those now used for Delta payloads.

For Space Shuttle flights; the PAM and its spacecraft will be mounted on a special cradle in the transport's cargo bay; for Delta launches, the PAM and spacecraft will be installed at the top of the boost vehicle's second stage in the same way Delta's present third stage and spacecraft is installed.

Moments before the PAM's launch from low orbit, the spin table is activated to give both PAM and payload a rotary motion which stablises their flight. The spring-loaded separation system releases the vehicle on command, pushing it gently out of the Shuttle cargo bay (or away from the Delta) before the Star 48 is fired to send the satellite toward its final destination.

U.S./CANADA SPACE SESSION

A team of officials from NASA, headed by NASA Administrator Dr. Robert Frosch, conducted a day-long session with Canadian Space officials on 19 September 1978, Minister of Communications Jeanne Sauve has announced. Canada participates with the United States in a number of joint programmes in space and one of the purposes of the visit was to exchange information about each country's future space programmes and plans.

The NASA team also toured the research facilities of the Department of Communications west of Ottawa, mission control for Canada's experimental and scientific satellites, and the facilities of the Canada Centre for Remote Sensing of the Department of Energy, Mines and Resources.

Mme. Sauve said the visit, the first to Canada by Dr. Frosch since assuming his position as NASA Administrator, was tangible evidence of the continuing close relationship between Canada and the United States in the space field.

SOLAR PIONEERS BEGIN 2ND DECADE

The Pioneer programme is especially remembered for its attempts to reach the Moon in the late 1950's and for its two spacecraft, Pioneers 10 and 11, which are still crossing the Solar System after returning the first close-up photographs of the planet Jupiter, writes Andrew Wilson.

Now another Pioneer subprogramme has made sure of its place in the history books because, on 8 November, its satellites had been operating in heliocentric orbit for ten years. The four solar Pioneer vehicles have returned an immense amount of data on solar and interplanetary physics and, now that the network has exceeded its design life, they have provided unique coverage of the Sun through its 11-year cycle, allowing scientists to more positively correlate solar events with disturbances in the Earth's magnetosphere.

The network was put to a more practical use during Apollo lunar flights by providing the Apollo Mission Control Center in Houston with hourly reports of solar activity to protect the astronauts against the unexpected arrival of showers of solar protons. This was particularly important in 1969 when the Sun was reaching a period of maximum activity.

In general, the mission of the solar Pioneers (Table 1) is to return data on the solar wind, high energy particles and magnetic and electric fields radiating from the Sun. Solar disturbance warnings are supplied to NOAA's Space Disturbance Center in Boulder, Colorado, for distribution to

Table 1. Solar Pioneer launches

Pioneer	Date	Wt. lb. (kg)	Launch vehicle
6 (1965-105A)	16 Dec. 1965	140 (63.5)	Delta 35
7 (1966-75A)	17 Aug. 1966	140 (63.5)	Delta 40
8 (1967-123A)	13 Dec. 1967	145 (65.8)	Delta 55
9 (1968-100A)	8 Nov. 1968	148 (67.1)	Delta 60
E (---- ----)	27 Aug. 1969	148 (67.1)	Delta 73

users such as airlines, power companies and communications organisations to warn them against radio blackouts. For example, information from Pioneer 7 during 22 April, 1969 led to predictions of a geomagnetic storm on 28 April. The storm arrived within three hours of the predicted time.

Orbiting satellites also have to be protected against charged particles because their solar cells and electronics are particle-sensitive.

The solar Pioneer began life as an informal study at Ames Research Center in May, 1960 with the results published in July, 1960 in an internal report entitled 'A Preliminary Study of a Solar Probe.' A formal Ames Solar Probe Team was set up the following September and NASA approved the definitive contract in July 1964.

In 1962, cost of the programme was estimated to be $30 million but the actual cost turned out to be nearer to $70 million, mainly because of the addition of a fifth flight vehicle (Pioneer E) and the unexpected long lives of the craft.

The Pioneers were designed to be rugged, high-performance vehicles with systems selected for their simplicity and reliability. The drum-shaped satellites are 35 in high and 37 in in diameter with solar cells on the curved outer surfaces to provide power for the experiments and vehicle systems.

As an example of the Pioneer's capabilities, Pioneer 8 was designed to carry seven experiments: 1. Magnetometer; 2. Plasma analyser; 3. Cosmic ray detector; 4. Cosmic ray gradient detector; 5. Radio propagation (electron density); 6. Electric field detector, and 7. Cosmic dust detector.

An additional investigation needed no equipment aboard any of the satellites – this was the celestial mechanics experiment which required long-term precision tracking of the craft in order to improve our estimates of the Sun-Earth-Moon mass ratios and distances.

Pioneer E, the fifth satellite in the series, was lost in a launch mishap because of a first stage hydraulic failure in the Delta launch vehicle.

MISSIONS TO SALYUT 6

Continued from page 133]

Acknowledgements

The author wishes to acknowledge the following sources: Novosti Press Agency; Polish Press Office; *Soviet News; Soviet Weekly; Moscow News*; Radio Moscow; Radio Warsaw; *Flight International*, and *Aviation Week and Space Technology*. Special thanks are due to Ralph F. Gibbons and Phillip S. Clark for their valuable assistance in compiling this article.

[To be continued

SATELLITE DIGEST - 124

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed summary of the information presented can be found in the January, 1979 issue, p. 41.

Continued from February issue, p. 92]

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Cosmos 1045 1978-100A 11084	1978 Oct 26.29 15000 years	-	-	1686	1707	82.55	120.43	Plesetsk C-1 USSR/USSR
Radio 1 1978-100B 11085	1978 Oct 26.29 15000 years	-	-	1685	1706	82.55	120.41	Plesetsk C-1 USSR/USSR (1)
Radio 2 1978-100C 11086	1978 Oct 26.29 15000 years	-	-	1686	1706	82.55	120.42	Plesetsk C-1 USSR/USSR (1)
Prognoz 7 1978-101A 11088	1978 Oct 30.224 10 years?	Spheroid + 4 vanes 950?	1.8 dia?	464	202970	64.91	5894	Tyuratam A-2-e USSR/USSR (2)
Cosmos 1046 1978-102A 11098	1978 Nov 1.50 12.8 days (R) 1978 Nov 14.3	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	202	327	72.89	89.87	Plesetsk A-2 USSR/USSR
HEAO 2 1978-103A 11101	1978 Nov 13 2 years	Tapered octagonal prism 3150	5.8 long 3.0 dia	523	542	23.51	95.08	ETR Atlas-Centaur NASA/NASA (3)

Supplementary notes:

(1) Pair of amateur radio satellites, launched as pick-a-back payloads along with Cosmos 1045. The satellites act as relays between amateur operators up to 8000 km apart. Built by Soviet college students, the satellites use uplinks in the 2 metre amateur band and downlinks at 10 metres. A Morse code identification beacon operates also at 10 metres.

(2) Scientific satellite studying the magnetosphere and carrying instruments for ultra violet and gamma radiation studies. Onboard equipment was manufactured in Hungary, Sweden, France and Czechoslovakia, as well as the USSR.

(3) Second in NASA's series of three High Energy Astronomy Observatories. HEAO 1 (1977-75A) was launched during 1977 August. HEAO 2 will make more detailed observations of X-ray sources identified by HEAO 1, using a number of instruments attached to a grazing incidence X-ray telescope. The satellite was designed with a twelve month operating programme in mind.

Amendments and decays:

1969-21A, Cosmos 269 decayed 1978 Oct 21, lifetime 3517 days.
1977-70A, Cosmos 933 decayed 1978 Nov 1, lifetime 467 days.
1977-77A, Cosmos 937 decayed 1978 Oct 19, lifetime 421 days. This satellite carried a micro-thruster which was used to modify the orbit considerably; between 1978 March and its decay, the orbit rapidly reduced from 430 x 446 km. Under conditions of natural decay, this would have taken about 6 years.

SPACE TRACKING AT ASTON

An expansion of the satellite research programme at the University of Aston has been announced as a result of a grant of £320,000 from the Science Research Council and the donation of two satellite tracking cameras by the Ordnance Survey.

Each camera worth £250,000 together with equipment valued at £100,000 brings the total package to almost £1 million.

The cameras, to be used in the tracking of Earth satellites, will be operated under the auspices of the SRC by Aston's Earth Satellite Research Unit under its Head, Dr. Clive Brookes (BIS Fellow) who described the award as "offering tremendous scope to increase the effectiveness of optical tracking." It would, he said, "put the University into the forefront once laser tracking became available in the United Kingdom."

The site of one of the cameras is near Pershore, Worcestershire, and the other – which is currently in Edinburgh – will be shipped to Australia so that satellite movement can be monitored in both the Northern and Southern hemisphere. The chosen location at Siding Spring in New South Wales is also the site of the 150 in (381 cm) Anglo-Australian Telescope and the United Kingdom Schmidt Telescope. The back-up service of the University's Earth Satellite Research Unit will be based in Aston's recently acquired St. Peter's College, Saltley, and will comprise laboratories and ancilliary offices manned by a staff of 15.

The main purpose of the optical tracking of selected satellites is to confirm and analyse their orbits. Optical analysis provides valuable geophysical information about the Earth's gravitational field and upper atmosphere, which either cannot be obtained at all by other methods or cannot be obtained as accurately. The orbital analysis method is extremely cost-effective because it utilises selected satellites launched by others rather than requiring special launches of satellites or rockets.

BOOK REVIEWS

The New Challenge of the Stars
Illustrated by David Hardy, text by Patrick Moore.
Published by Mitchell Beazley in Association with
Sidgwick and Jackson, 1978, pp 62, £4.95.

We live in an age of technological development where yesterday's dreams become present reality. The technology "explosion" in modern astronomy is forcing the most recalcitrant planets to yield up secrets. Man made space probes fly past and busily scan, or sometimes cross the gravitational doorstep, settle down, "breath" the air, look at the landscape, and then tell Earth all about it.

Fortunately, artist David Hardy is able to keep abreast of most of these developments – may his brush never wear out! For in 34 superbly coloured plates – 10 of them being double page spreads – he accurately illustrates some of the latest findings, and then goes on to depict the scenes that may be witnessed by our descendants.

We of the present generation can use them either to absorb as art images with semi abstract forms, or – possibly more important – use them as aids and concepts for ideas and theories which may lead to useful new hypotheses. For those who wonder how a Black Hole could look to the human eye, a glance at pages 54 and 55 may assist. It could also give insight to developments in technology. A stranded starship is being repaired by intelligent vehicles, simply because the radiation emanating from the star system is too intense for even a heavily shielded astronaut to venture into the open.

Half of the paintings are space fiction and fantasy but they inevitably provide a basis for anthropomorphic ideas and thoughts. One picture which provides such stimuli concerns an Interstellar Ark formed from a hollowed out asteroid. Driven by ion rockets, and carrying a generation that has never lived on the surface of a planet, it is manoeuvring to take up a stable orbit around a planet with Earth-like characteristics. But there is a reception committee awaiting their arrival . . .

Patrick Moore's text is – as one would expect – up to date and informative in concise crisp language. The format is geared not only to the amatuer astronomer but to anyone who is naturally inquisitive. It is a book that can be read by young and old alike.

The pictures are, of course, the main attraction, and earlier in this review I mentioned keeping abreast with "most of the developments". Although it is mentioned in the text, I suspect that the discovery of the rings of Uranus was announced just too late for Hardy to produce an illustration that was accurate and could meet a deadline. A wise decision, for the latest work indicates possibly as many as 8 narrow rings around Uranus, and matters are not fully settled.

But this is a minor criticism of what is a good example of modern art in a healthy form. Accuracy in space art, combined with beauty in format and design is achieved only by a small group of whom Chesley Bonestell was the pioneer. His paintings, combined with Willy Ley's text stirred men's minds to the possibilities of space stations and lunar landings.

The torch has been firmly grasped and is carried in the illustrations and text of this book.

May that torch in turn by handed on and may it light Man's way to the stars.

A. T. LAWTON

On The Shoulders Of Titans : A History of Project Gemini
By B.C. Hacker and J.M. Grimwood, NASA SP-4203, 1977,
U.S. Government Printing Office, Washington, D.C. pp. 625
$8.25

Following on from the well received history of Project Mercury, the official history of the next manned space programme, Gemini, has been published by NASA.

The authors open the history with the comment,*'Project Gemini is now little remembered, having vanished into that special limbo reserved for the successful intermediate steps in a fast-moving technological advance!.*

While not in full agreement with the writers, the reviewer was pleasantly surprised in being reminded of aspects of Gemini which had fallen from immediate memory.

Gemini was conceived as the step between Mercury and Apollo when it became apparent the gap between the two would be too great for the state-of-the-art in 1961. While Gemini was being discussed, the best way to the Moon had not even been decided upon but it was realised that orbital rendezvous, the great unknown of the early 1960's, would be vital. Gemini was in. The plan, on paper, appeared very simple: Mercury was the experimental spacecraft and Gemini would be the production phase – for a long time before officially becoming 'Gemini', the tag 'Mercury Mark II', was used.

Gemini would not be expensive, simply because it would use upgraded Mercury technology. Additional to this technology would be the use of the paraglider for landing on dry land, the Lockheed Agena as rendezvous and docking target and the Air Force Titan II as launch vehicle. An air of optimism pervaded the project – after all, Mercury was working and Gemini was merely an extension. When attempts were made to convert the paper plans into hardware the problems showed up, Gemini turned itself into a whole new spacecraft development and costs were the only things to rocket upwards.

The paraglider was a massive failure after North American spent years on preliminary tests, Titan II looked as if it would never fly to manned standards, the Agena was almost struck completely from the programme and the spacecraft thrusters were near failures. On top of that, Secretary of Defence, McNamara proposed merging NASA's Gemini with the USAF version (Gemini //Manned Orbiting Laboratory) and giving the combined effort to the Department of Defence. NASA, naturally, were aghast and even the USAF was taken by surprise. Luckily for NASA, McNamara was eventually persuaded to drop the scheme.

The history brings out these setbacks and project revisions in great detail, though this is an "official" history, and, sometimes, dry facts become a little too dry. Having said that, this is an absolute must for all interested in spaceflight – all the background information is there. However, the early days do seem to be covered at great length, perhaps at the expense of the flight descriptions. The photographs are those seen many times before, but the first photograph of a manned spacecraft from the exterior, taken by Ed White on Gemini 4, has been omitted. Yet this is intended to be a history of the programme. The authors could, and probably do, argue that this volume is to be taken together with the other Gemini chronologies and summary reports published.

In summary, the criticisms are few. Most *Spaceflight* readers should have this volume on their shelves.

ANDREW WILSON

SOCIETY NEWS

SPACELAB AND YOUNG EUROPEANS

An imaginative opportunity for young people to fly experiments on board Spacelab is being offered by the European Space Agency. Preliminary information is given in the ESA document "Access to Spacelab for Young Europeans" (ESA/DP/ST(78)2).

The programme has four main objectives:

- To *popularise* as widely as possible space research and technology. At the start of the space era public opinion was very favourable to new experiments. Now opinion is less interested in these experiments and there is a fear that within a few years an anti-space movement could develop. It is important to illustrate therefore that space experimentation, while providing new openings in science may, thanks to its new applications, be of benefit to mankind.
- *To arouse interest* in educational circles.
- *To encourage* the introduction of young people to the European idea: the selection of ideas and experiments will bring into contact young people in scientific clubs in the various countries.
- *To encourage* the development of scientific and technical hobbies for young people: such leisure-time activities may stimulate interest in technological studies, in manual work and to a lesser degree, in artisan skills.

The proposals from groups of young people should be sent in by youth clubs and associations. Four levels of technical complexity are suggested for these proposals:

(1) promotion of ideas by organising drawing and illustration competitions on the general theme of using space for peaceful purposes and international cooperation,

(2) possibility of access to data from scientific experiments carried on Spacelab,

(3) proposed low technology experiments (not in any pejorative sense: e.g. following the growth of a plant on Spacelab under the supervision of an astronaut),

(4) proposals for experiments introducing a technical development.

The European Space Agency has prepared a Spacelab utilisation programme for experiments for teaching and educational purposes; experiments in zero gravity can more readily illustrate certain general laws of physics. This programme was the subject of a report (DP/ST(77)3) prepared by the ESA Working Group on space experiments for the teaching of physics. It was mainly of interest to teachers but a link may be profitably made between the activities described here and those concerned with promoting *scientific hobbies.*

It is important to adapt the aims of the operation to young people's abilities and interests. Three age groups are suggested:

The 15 to 19 age group, probably the easiest group to contact with the minimum of intermediaries, by using television, radio and the educational milieu (both inside and outside of school). It is in this age group that it can be reasonably expected to motivate young people and youth clubs for a period of about two years, which is compatable with producing an experiment involving some technology.

It is from this age group that we can expect proposals of a scientific type involving some technological effort. But it must be pointed out that the objectives of the operation would not be attained if the proposals from this age group came solely or mainly from young people intending to pursue lengthy higher educational studies. It is often in the 15 to 16 age group that young people are interested in technical problems and are more open to ideas of friendship and cooperation between peoples: it is the age when a young person chooses a technical or manual trade which is often more suited to his taste than a profession within the tertiary sector.

The 10 to 14 age group represents an age which is essential for popularising space through the promotion of ideas: poster or design competitions could be introduced to illustrate the main Spacelab missions and through such activities it would probably be possible to establish links between school children of different nationalities.

Contact with this age group is nevertheless more difficult than with the previous group (radio can scarcely be used) and the approach *via* the educational milieu and parents should be such as to avoid any "blockage."

The 19 to 25 age group which, unlike the other two would be more university-linked. It would be hoped that this age group would contain young workers, but because of the break due to military service it will probably mainly concern young people engaged in higher education, either a short cycle (up to 21) or a longer cycle (up to 23). Pro-

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BIS DEVELOPMENT PROGRAMME

SPACE DISPLAYS

The Council would like to explore the possibility of arranging small displays in our new offices likely to interest visitors.

Among those suggested are items of an historical nature, special collections on particular space projects, small space artifacts, etc.

Members possessing such material which they would like to display in the Society's offices for a limited period, are invited to send full details to the Executive Secretary.

A Special Invitation to Overseas Members

A particular invitation is extended to overseas members to help initiate subsequent Society collections for display purposes.

Some of the suggestions where they might help are as follows: –

(1) First-day covers, etc. especially if depicting special stamps of an astronomical or space nature.

(2) News cuttings, photographs, decals (i.e. stickers), badges and similar material.

(3) Christmas cards of a space orientated nature.

(4) Items of historical interest,e.g. early books, magazines, postcards or similar materials relating to space.

posals from this age group should be less imaginative (being "polluted" in a sense by studies) but more mature and better prepared technically.

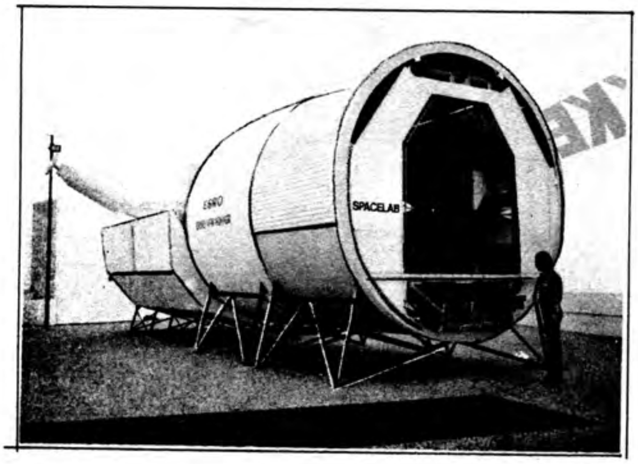
It is expected that certain requests will come from laboratories anxious to get into space science and technology and which would see in this approach a means of becoming familiar with space technology requirements.

Whatever the age group involved, for circulating projects, collating and coordinating proposals, the following should be used in each European country:

- any existing scientific associations and clubs
- youth section of scientific associations
- official departments interested in youth and education problems
- official departments responsible for science and technology
- national media

A full information document to be issued shortly by ESA will be followed by a call for proposals towards the end of the year. A screening body will be formed in each Member State to handle the proposals.

We are indebted to Mr. D. J. Shapland of the Spacelab Directorate for making preliminary information available to the Society.



Full size mock up of the European Spacelab which will accommodate a wide variety of experiments for the international scientific community aboard the NASA Space Shuttle.

ERNO Raumfahrttechnik GmbH

ERRATA *Photo captions*

Mr. Ray Ward has pointed out that in the second part of article. "Where are they now?" (*Spaceflight*, September-October 1978) the caption referring to the Group 3 astronauts on page 328 is incorrect. The two top lines of reproduced signatures should read as one line, left to right, up, down, up, down etc., and the correct order of the standing astronauts should therefore be: Collins, Cunningham, Eisele, Freeman, Gordon, Schweickart, Scott, Williams. A similar mis-reading occurred in the captioning of an astronaut photograph which appeared in our issue of July 1978, p. 275, as noted by Jonathan C. McDowell (*Spaceflight*, December 1978, p. 444). Ed.

SPACEFLIGHT

BIS DEVELOPMENT PROGRAMME

NEW MEMBER DRIVE

INCREASED MEMBERSHIP is essential if our plans to enlarge and improve Society activities are to succeed.

ALREADY MANY IMPROVEMENTS are in hand – *Spaceflight* is now 48 pages, valuable new issues of *JBIS* are planned, our new offices are nearing completion, and all this with NO CHANGE in basic rates for THREE YEARS – FIVE YEARS in the case of overseas members who pay in dollars – incredible when prices around are doubling every four years.

Future plans depend heavily on an increased membership, so we are seeking help from every member to work with the Society to attract new members.

Society membership details will be sent immediately upon request, either by telephone or letter. All we need is the name and address to which they are to be sent.

IN APRIL WE WILL INCLUDE, IN THE CENTRE PAGES OF *SPACEFLIGHT*, FOUR APPLICATION FORMS. PLEASE PUT THESE TO GOOD USE.

Spaceflight is a good selling point. It now carries improved illustrations, a most active correspondence section, full-length articles on leading space developments and an extensive news coverage on:-

- International and national events in space.
- The US and USSR space programmes.
- Present and future developments in space. astronomy and related subject areas.
- Informative technical articles.
- News reports.
- Reviews and readers' correspondence.

Here are some of the things members say about it:

May I offer my congratulations on the new format 'Spaceflight.' I look forward to the excellent article that will follow in the wake of the Venus and Voyager probes. 1979 will truly be a vintage year.

G. HUGH CAVES

Congratulations on the increased pages and contents of 'Spaceflight,' especially the Astronomy Notebook, a welcome addition. It should help me to enrol a friend as a member.

I. HARDY

I recently tried to help project 'Spaceflight' to lift-off by taking some issues to my local Astronomy club, but when I tried to get them back there were many issues missing. Could you send me some more copies of 'Spaceflight' so that I can, in future, promote project 'Spaceflight' at less risk.

L. GUNNAR PIL

JBIS journal of the british interplanetary society

The 12 monthly issues of *JBIS* for 1979 cover a wide range of technical space topics and with special selections on: *SPACE SCIENCE AND EDUCATION; SPACE TECHNOLOGY; SPACE APPLICATIONS; SPACE HISTORY and INTERSTELLAR STUDIES.*

The contents of the issues which have been published since the last list (*Spaceflight*, Jan. 1979) are given below.

Members can obtain the 12 copies of *JBIS* for 1979 for £11.50 ($23.00) postage inclusive. The four *INTERSTELLAR STUDIES* issues can be obtained separately for £4.00 ($8.00). Single copies of any issue may be purchased at £1.00 each ($2.00) post free.

Orders can be included in the annual subscription renewal notice or sent separately to:
Executive Secretary, British Interplanetary Society,
12 Bessborough Gardens, London, SW1V 2JJ, England.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 12 Bessborough Gardens, London, SW1V 2JJ: Tel: 01-821 9371.

Correspondence and manuscripts intended for publication should be addressed to the Editor 12, Bessborough Gardens, London, SW1V 2JJ.

Opinions in signed articles are those of contributors, and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Western Branch
Topic **FILM SHOW**
To be held in the Physics Lecture Theatre, G.4Z, Tyndalls Avenue, University of Bristol, on **2 March 1979** at 7.15 p.m.

The programme will be as follows:
(a) Remote Possibilities (b) The Weather Watchers
(c) If One Today, Two Tomorrow (d) The Mission of Apollo Soyuz

Admission tickets are not required. No University car parking facilities are available but there are Public Car Parks at Park Row, Berkeley Place and limited road parking around the University.

General Meeting
Title **SPACE MISCELLANY – 2**
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **8 March 1979** 6.30-8.30 p.m.

Two contributions will be presented:

(1) Phil Parker will travel down memory lane with Apollo Reminiscences.

(2) David Early will discuss and exhibit some of his Space Paintings

Members interested in presenting short contributions to later meetings of this nature are invited to send details to the Executive Secretary.

Admission tickets are not required. Members may introduce guests.

Lecture
Title **ASTRONOMY FROM ORBIT**
by Dr. W. I. McLaughlin (*J.P.L.*)
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **4 April 1979**, 6.30-8.30 p.m.

Admission tickets are not required. Members may introduce guests.

General Meeting
Title **SPACE MISCELLANY – 3**
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **9 May 1979**, 6.30-8.30 p.m.

Two contributions will be presented:

(1) Satellite Tracking – Some Problems and Results by M. Sweeting.

(2) Space Shots – With a Difference by J. I. Stone

Members interested in presenting short contributions to later meetings of this nature are invited to send details to the Executive Secretary.

Admission tickets are not required. Members may introduce guests.

30th IAF Congress
The 30th Congress of the International Astronautical Federation will be held in the Deutsches Museum, Munich, Germany from **17-22 September 1979**.

Further details will be published as soon as these come to hand.

BIS members, both from the U.K. and overseas, who plan to attend the Congress are asked to notify the Executive Secretary accordingly.

3rd BIS CONFERENCE ON INTERSTELLAR STUDIES

To be held in the Chemistry Lecture Theatre, University College London, Gordon Street, London, W.C.1., on Tuesday and Wednesday, **11-12 September 1979**. (Note change in dates).

The scope of the Conference is intended to cover all aspects of Interstellar Studies, including such topics as:

- Propulsion concepts
- Interstellar probes
- Extra-solar planetary systems
- Laser and radio communication
- Evolution of life
- Rise of intelligence and civilisation

It is planned to allow ample opportunity for discussion to take place among the participants, both informally and in final discussion sessions.

Papers presented at the Conference will be published in the Interstellar Studies issues of *JBIS*, following usual reviewing procedures.

Applications for registration forms and notification of the intention to submit a paper for the Conference, should be made to: The Executive Secretary, British Interplanetary Society, 12 Bessborough Gardens, London, SW1V 2JJ, England.

16th EUROPEAN SPACE SYMPOSIUM

Theme: **CURRENT AND POTENTIAL EUROPEAN SPACE PROJECTS**

To be held in Stresa, Northern Italy, on 3rd - 5th July, 1979, co-sponsered jointly by the DGLR, AAAS, AIDAA and BIS.

Technical Sessions will be devoted to the following main subject areas.

(1) Spacelab and Supporting Activities
(2) Technology of Space Vehicles (Satellites and Launchers)
(3) Space Applications
(4) Future Trends

Offers of Papers are Invited. Please contact the Executive Secretary for further information.

Programmes and Registration forms will be available on request in due course.

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SPACEFLIGHT

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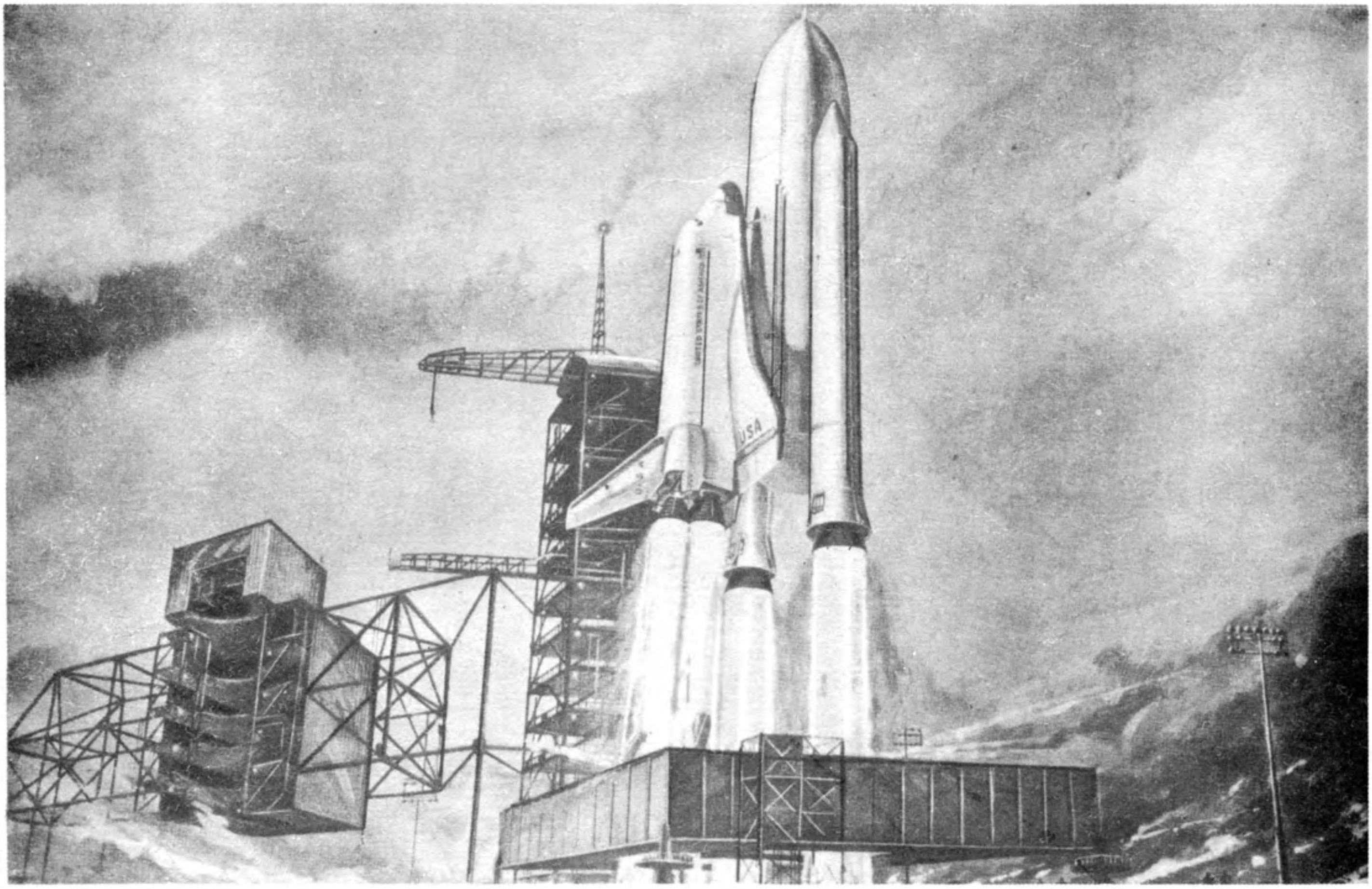

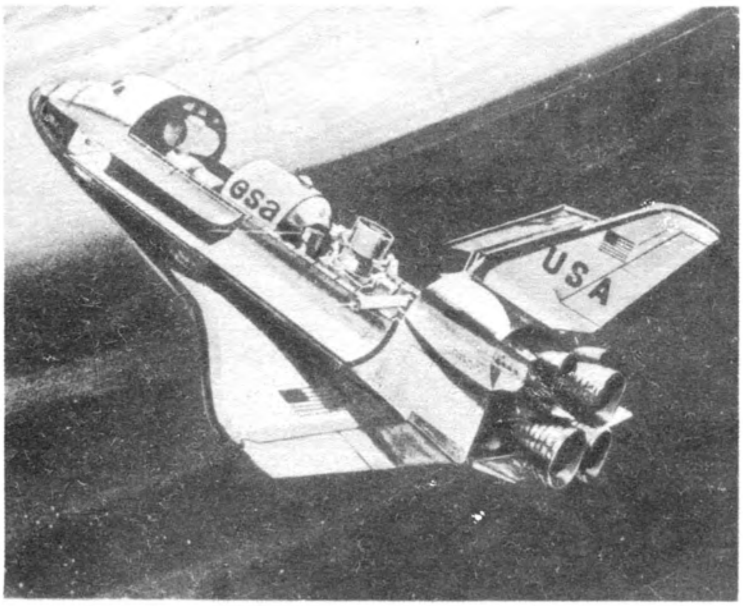

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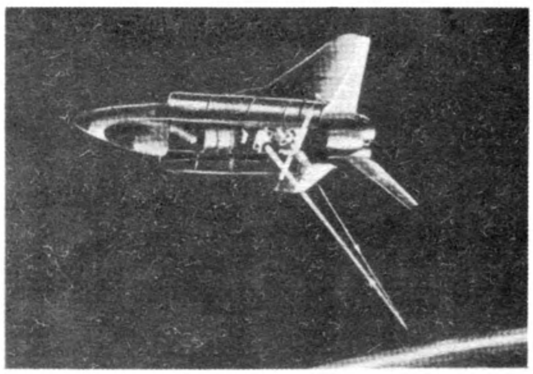


WILL YOU HELP US WITH A DONATION

We thank all of our members who have given so generously to our Development Appeal.

The total received, just before going to Press, was as follows:

TOTAL 31 JANUARY 1979 £31,445

The Society's finances are now under very heavy pressure due to payments for construction work and equipping the building. Every extra bit of income is important at the present time and any contribution which you feel able to make will be immediately applied to this urgent and vital work. Whatever you can give will definitely count. Please give generously.

These are just a few of the many expressions of support which we have recently received from members.

I enclose a cheque for £10 for the BIS Development Fund. I am very pleased to be able to let you have my third donation and during 1978 I have read with interest in *Spaceflight* of the good progress being made in the reconstruction work which I am sure will make a worthy permanent headquarters for our Society. When we have our own building in use for headquarters staff, library, meetings, etc., I believe this will assist greatly in furthering the aims of the Society and increasing our membership.

J. E. SCOTT

I also enclose my sixth donation to the Development Fund and wish you all the best in the future.

M. E. HARVEY

This latest enclosed contribution to your Development Fund Appeal should have been part of my son Lukes Christmas Present (5 months old), but I thought it would probably benefit him more if I invested it in his future through yourselves.

M. SWAIN

Congratulations to the Society on attaining its initial projected target of £25,000. I look forward to being at the opening of the Society's new headquarters in 1979. I hope that, on that auspicious occasion, representatives of the communications media will be present to publicise the existence, growth, past achievements and future goals of the Society.

STEPHEN ALSFORD

Please add the balance left over to your new building appeal – to which I shall contribute later on as well. I only wish I had known about your magazine before; you may be sure I shall recommend it to others whenever the opportunity presents itself.

With all my best wishes for continuing success in your publications and excellent space work.

PAUL KARADZAS

Please send your gift to:

EXECUTIVE SECRETARY, MR. L. J. CARTER

BRITISH INTERPLANETARY SOCIETY

12 Bessborough Gardens, London, SW1V 2JJ.

VIII IFAC SYMPOSIUM: AUTOMATIC CONTROL IN SPACE

Oxford, UK 2-6 July 1979

Sponsored by: International Federation of Automatic Control (IFAC).

Organised by: The Institute of Measurement and Control on behalf of the United Kingdom Automatic Control Council (UKAC) and co-sponsored by The British Interplanetary Society.

Topics

The IFAC Space Committee is concerned with the areas of:

- Automatic control
- Open and closed loop control and stabilisation
- Man-in-the-loop control
- Remote control
- Combinations of these modes.

in space and space related investigations and applications of which some specific fields are:

- Space launch and landing systems
- Spacecraft and satellites (including rendezvous problems)
- Space laboratories and telescopes
- Aerospace systems
- Planetary and earth/space related surface systems
- Use of spacecraft and terrestrial navigation
- Underwater systems
- Inertial systems for underwater positioning
- Manipulators, tele-operators
- Space experiments
- Navigation, guidance and control systems (including components such as sensors, effectors and power control)

Offers of papers are invited for presentation at this meeting. Further information is available from the Executive Secretary, British Interplanetary Society, 12 Bessborough Gardens, London, SW1V 2JJ.

SPACEFLIGHT

A Publication of The British Interplanetary Society

VOLUME 21 NO. 4 APRIL 1979 *Published 15 March 1979*

Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

CONTENTS

SPACE SHUTTLE RE-SCHEDULED. First orbital flight of the Space Shuttle (102) crewed by astronauts John Young and Robert Crippen has been postponed from 28 September to 9 November largely because of an engine failure during a static test in December. The fault was traced to the main liquid oxygen valve and NASA has decided to modify all engines before further engine tests are made. *Top*, artist's impression depicts a Space Shuttle lift-off with all engines burning in parallel. *Bottom left*, first flight with the European Spacelab is expected in late 1980. *Right*, Lidar probing of the upper atmosphere.

Rockwell International Space Division/National Aeronautics and Space Administration

MILESTONES

January

4 Voyager 1, now 598 million kilometres from Earth, 16 months after launch, begins three-month systematic observation of the planet Jupiter and its major moons. Eleven comprehensive scientific experiments are planned and more than 15,000 photographs should be taken. Closest approach to the planet will occur on 5 March 1979. After passing Jupiter and also studying the moons Io, Europa, Ganymede, Callisto and Amalthea, Voyager 1 will begin a 20-month cruise towards the ringed planet Saturn.

8 NASA forward planning includes Venus orbiting imaging radar mission for 1984 encounter and possible near-term cometary mission. One possibility, if funded in FY 1981 budget, is a flight through Halley's comet (1986) to intercept comet Tempel 2. NASA/JPL report is due this summer.

8 *Aviation Week and Space Technology* reports that "U.S. reconnaissance spacecraft have detected the Soviets constructing a large new runway at the Tyuratam launch site. The runway is being built to facilitate the horizontal landing of the new winged re-usable manned spacecraft now under development...." (see "A Soviet Space Shuttle?", *Spaceflight*, September-October 1978, pp. 322-326).

10 NASA announces that first High Energy Astronomy Observatory (HEAO 1) has exhausted its supply of attitude control gas, ending a 17-month mission to survey and map X-ray sources. The satellite achieved three important results: (1) The catalogue of celestial X-ray sources was increased from the 350 previously known to a total of nearly 1,500. (2) A new black hole candidate was located near the Constellation *Scorpius*, bringing the total to four. (3) A universal hot plasma constituting a major fraction of the mass of the Universe was discovered, as well as a cloud of dust and gas with a mass equal to a million billion (US) Suns enveloping a super-cluster of galaxies. This discovery suggests that there is probably sufficient mass to 'close' the Universe (i.e., preclude its expanding forever).

11 Recommendations by U.S. National Research Council's committee on planetary and lunar exploration include proposals for: • Joint U.S./Soviet unmanned mission to Venus. • Attempt to return core sample from far side of Moon with Soviets supplying the lander and the United States a geo-chemical lunar orbiter. • Intensive study of limited areas of Mars to establish chemical, minerological and petrological characteristics of different surface materials.

[Continued overleaf

JOINING THE INTERNATIONAL SPACE ADVENTURE

Our new Headquarters Building, to be opened later this year, gives us a unique opportunity to take further vital steps in our Development Programme, to enlarge our membership and bring greater financial resources to bear. We are therefore asking each existing member to join us in promoting a vigorous membership campaign world-wide. In the centre pages of this issue readers will find two Application Forms for membership in the British Interplanetary Society. **Will you – please – use them to help build the New BIS by introducing friends and colleagues to our adventure?**

В журнале не печатается ряд страниц.

Milestones/contd.

16 Ford Aerospace and Communications Corporation orders two McDonnell Douglas Payload Assist Module (PAM) rocket systems to help launch satellites the company is developing for the Indian Government. PAM systems are to boost the INSAT weather and communications satellites into geosynchronous transfer orbits after ejection from the cargo bay of the Space Shuttle.

16 Senator Adlai E. Stevenson, III (Democrat. Illinois) tells National Space Club: "Pressures are on to cut the (space) budget. And the Congress and the Executive will be attempting to define U.S. policy for a new era in space in this new year and new Congress. A feverish, uncertain government will make decisions that could be as fateful to the country's future in space as those of the early 1960's...."

16 Project scientists at the Marshall Space Flight Center in Huntsville, Alabama, report that the three scientific experiments to be carried aboard NASA's third High Astronomy Observatory (HEAO-C) – scheduled for launch in September – have now been electrically integrated with the spacecraft. This operation verifies the assembly of the Observatory which culminated in the physical mating of the two major elements, the experiment module and the spacecraft equipment module. HEAO-C will conduct a survey of gamma-ray emissions and study cosmic ray particles from space.

17 Ariane Launcher Programme Board of the European Space Agency approves revised timetable of test flights for the launcher at Kourou, French Guiana: LO1 – early November 1979 (originally June 1979). LO2 – early March 1980 (originally December 1979). LO3 – June 1980 (originally May 1980). LO4 – October 1980 (unchanged). The revision of the timetable results from an incident that occurred on 28 November 1978 during a test of the third-stage propulsion system. An enquiry conducted by the project team at CNES concluded that the cause was "a malfunction of a safety device on the ground, which does not call the stage design into question." Despite the revised timetable, the date of the LO4 flight remains unchanged. "This enables the launcher's operational availability date of December 1980 to be maintained, thus leaving a margin of four months before the first user launch: ESA's Exosat, scheduled for April 1981."

18 NASA's Marshall Space Flight Center in Huntsville, Alabama, reports that the total number of public visitors increased by more than 100 per cent last year. Presence of Space Shuttle components (Orbiter, External Tank and Solid Rocket Boosters) – and the Center's efforts to enable as many people as possible to see them – was responsible for the jump from 123,765 in 1977, a fairly typical year, to 292,997 in 1978. The larger portion of visitors came to the Marshall Center *via* bus tours conducted by the nearby Alabama Space and Rocket Center.

19 NASA accepts report of the Board convened to investigate the power failure on board the Seasat spacecraft on 9 October 1978, after 105 days of satisfactory operation. Report identifies source of the failure as an electrical short in the slip ring assembly of the solar array, possibly triggered by wire-to-brush assembly contact, brush-to-brush contact or contamination.

22 U.S. Federal Budget for 1979-80 is sent to Congress Defense budget, set at $135,500 million, includes strengthening of U.S. nuclear deterrent forces and new high-technology weapons. Provision is made for accelerating development of MX inter-continental ballistic missile, continued procurement of Trident submarines and associated missiles, and improved nuclear warheads for missiles. Studies will be made of a new intermediate-range ballistic missile for possible deployment in Europe to counter threat of Soviet SS-20 which operates from mobile launchers. Space budget, which excludes 'new starts' in interplanetary exploration (e.g. Venus imaging radar mission, comet interception) is set at $4,725 million (which compares with last year's $4,566 million) plus recent $185 million supplementary request. (*Total increase is insufficient to keep up with inflation. – Ed.*) Main change reflects shift of emphasis in Space Shuttle programme from development to production; planned spending of $610 million for development compares with $1,170 million for FY 1979. Comparative production figures are $755 million (FY 1980) and $458 million (FY 1979).

23-25 Scientific investigators and NASA mission management for second Spacelab mission is held at NASA's Marshall Space Flight Center, Huntsville, Alabama. Present are Payload Specialist crew of four and a crew representative from JSC. The Spacelab 2 crew members are all from the United States. *(The first Spacelab crew, which is already in training, includes two Americans and three Europeans. – Ed.)* Spacelab 2 will contain experiments designed to probe outward from Earth.

COUNCIL NOMINATIONS

Nominations are invited for the Council Election to be reported to the ?4th Annual General Meeting which will be held on 13 September 1979.

In response to suggestions that more information about each Candidate should be provided, a revised Nomination Form has been prepared for use this year. Copies are available on request to the Executive Secretary, enclosing a foolscap reply-paid envelope.

Each Candidate accepting Nomination will need to sign the Form and must be proposed and seconded by other members whose signatures should also appear.

The last date for the receipt of Nominations is *21 June 1979.*

If the number of nominations exceeds the number of vacancies, Ballot Papers will then be prepared and circulated to all members as soon as possible to enable voting to take place.

Introduction

White Sands, New Mexico. To many, that name conjures up visions of V-2 rockets rising up off the desert in the late 1940's.... but little else. For the past 30 years, programmes conducted at facilities in and around White Sands have played an important role in man's conquest of space. These programmes have drawn upon the works and talents of scientists and engineers, administrators and theoriticians, both here and abroad, whose efforts over the years have made the dream of space travel a reality. A new museum; the International Space Hall of Fame has been built at nearby Alamogordo, New Mexico, to preserve the artifacts of these programmes, and to honour all of the pioneers of space.

The Region

The ISHF is located in the Tularosa Basin of southern New Mexico. Millions of years ago, the basin itself was formed by down faulting of a huge block of the Earth's crust leaving the 4,000 ft. high basin floor surrounded by rugged mountain ranges to the east and west. For centuries runoff from rain and snow has dissolved massive layers of gypsum in the mountains, transporting it to the valley below. There the arid southwest wind continually evaporates the water leaving behind a gypsum-crystal encrusted dry lake bed. Weathering disintegrates the crystals into glistening white grains which are swept away by the wind into huge white dunes: the White Sands which cover several hundred square miles of the southwestern corner of the basin. In 1933, 234 square miles of the dunes were set aside by the federal government for a National Monument, administered by the National Park Service. It is the largest concentration of gypsum in the world, and would require a freight train extending around the world several hundred times to haul it away!

Archeological evidence indicates that man first set foot in New Mexico some 20,000 years ago. Various Indian cultures evolved in the region reaching their zenith around the 13th century. The Spanish, expanding their New World empire, arrived in the mid 1500's. Santa Fe was founded 10 years before the Pilgrims arrived in Massachusettes.

The slowly increasing white population in the Territory in the 1800's gave rise to many "tales of the old southwest," the most famous being those of Billy the Kid and John Chisum (of Chisum Trail fame) and the Lincoln County

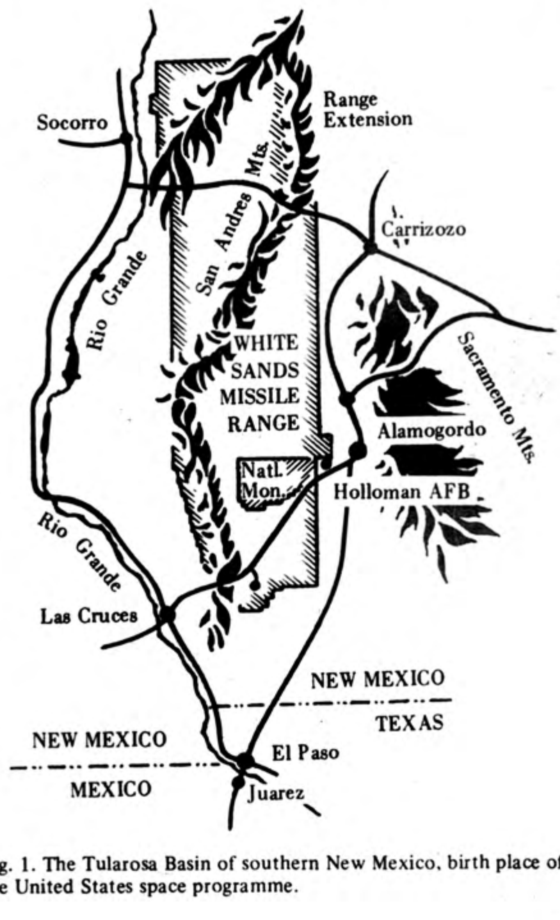


Fig. 1. The Tularosa Basin of southern New Mexico, birth place of the United States space programme.

Range War, just to the east of the basin. The U.S. Army, stationed at Fort Bliss near El Paso provided protection for the basin's white settlers from raids by the Mescalero Apache led by their famous chief Geronomo.

The V-2 Era

The harsh, dry climate in the region, however, has always kept the population sparse. It was this quality plus the consistantly clear weather that brought Dr. Robert Goddard to nearby Roswell to conduct his liquid fuelled rocket experiments in the 1930's. Unfortunately, limited documentation of his work meant that much of his results went unappreciated until many years later.

After the defeat of Germany in World War II, the U.S. Army captured a number of V-2's and missile production facilities, such as the underground V-2 factory in what was to become East Germany. By this time the Russian Army formally took possession of the area, the factory had been stripped and 300 freight cars loaded with V-2 components were on their way to the West. Their destination was the newly established White Sands Proving Ground in New Mexico.

The site for the WSPG had been selected by the Ordnance Corps of the U.S. Army in February 1945 after evaluating a number of candidate locations. It was near the Army's existing facilities at Ft. Bliss and the Alamogordo Army Air Base. It consisted mostly of federally controlled land (the White Sands Monument included), had good roads and rail service, its launch and impact areas were flat insuring easy access, and the consistently clear weather meant good visibility for tracking. The 40 x 100 mile grounds was formally established on 9 July 1945, just seven days before the explosion of the first atomic device at Trinity Site in the remote upper range. The first rockets to rise up from the WSPG were the WAC Corporals starting in late September 1945.

The V-2 components from Germany were trucked into the proving grounds right after the end of the war and preparations made to conduct a series of firings. German personnel, from Peenemünde, led by Dr. Wernher von Braun had also arrived making Ft. Bliss their base of operation to aid in this project. Unfortunately, even though several thousand war-time firings had been made, the only

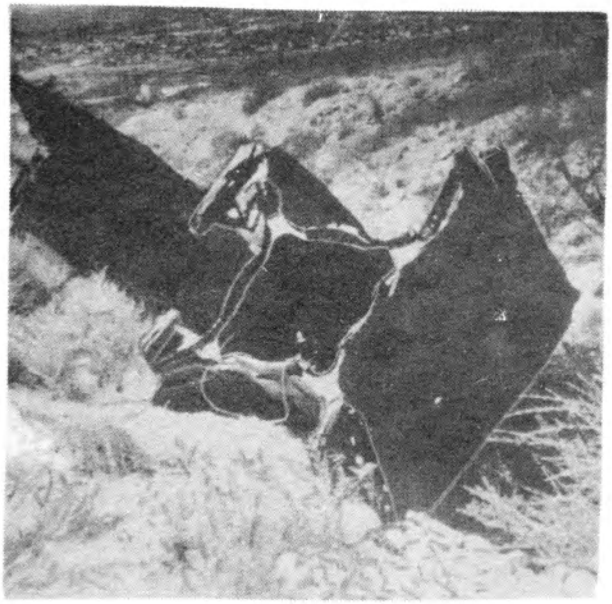


Fig. 2. V-2 tail sections an urbine pump assemblies scattered over a setting representative of how they were found out in the desert after a launch many years ago.

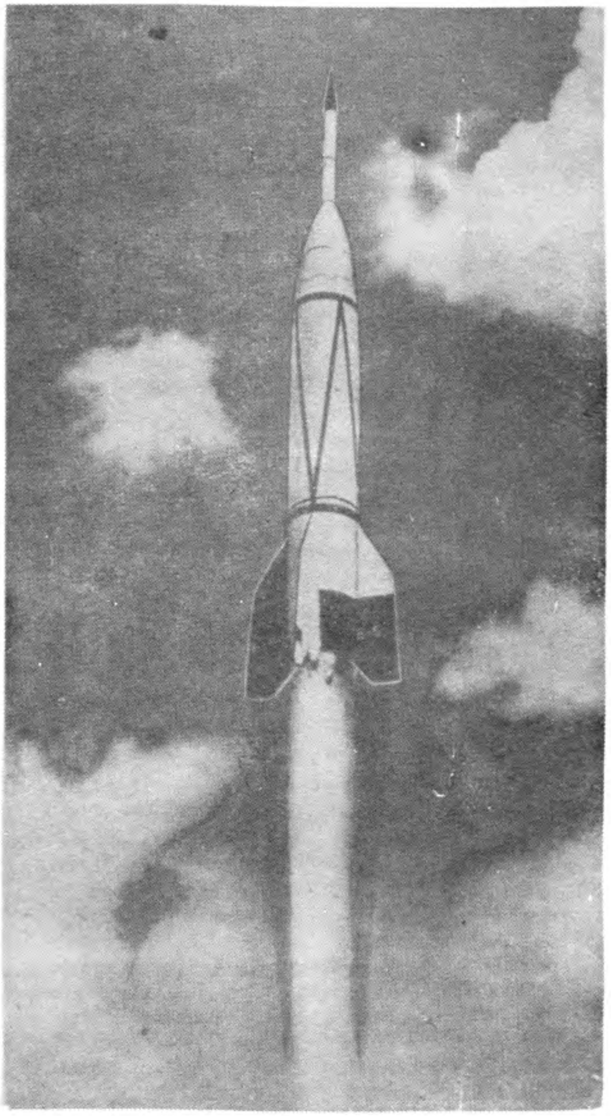


Fig. 3. A V-2 rocket carrying a WAC-Corporal – the historic shot on 24 February 1949 which carried to 243 miles the first man-made object to reach the vacuum of space.

U.S. Army

V-2's in the U.S. possession were mostly in various stages of completion. The quality of the components, produced in the frantic final days of the war, usually meant that some reworking was necessary. To complicate matters, there was little organisation to the collection of captured components then stored at WSPG, and documentation for assembling the rockets was poor. Nevertheless, 68 V-2's were assembled for launchings which continued through 1951. The first rocket launched on 16 April 1946 lost a fin and crashed near the launch site. The next one, three weeks later reached an altitude of 70 miles and impacted 31 miles up range: typical of the many successful launches that followed. Each rocket was equipped with telemetry monitoring sensors and an emergency cut-off. The cut-off was used for a launch on 29 May 1947 when a V-2, nearing burnout, suddenly shifted course and started heading south. The cut-off came too late as the rocket arced over El Paso and came crashing down into a cemetary in Juarez, Mexico at more than 3,000 mph. There was a huge explosion on impact, caused by the propellant left over after cut-off. Another mishap showered debris over Alamogordo. A technique of explosively

Fig. 4. Chimpanzee Ham in the padded contour couch of a Project Mercury capsule at Cape Canaveral 31 January 1961. The talented primate operated psychometer equipment in the capsule to help determine whether the first human astronaut would be able to perform similar mental-motive tasks. Ham received his training at Holloman Air Force Base, where a primate testing programme continues under direction of Albany Medical College.

Photo: Holloman Air Force Base

separating the nose from the body during descent was used to aid in payload recovery. While they could never be used a second time, the V-2 bodies were usually found surprisingly intact.

Instrumentation, carried aloft by the V-2's provided the first direct measurements of the air density profile, high altitude winds, cosmic rays, astronomical spectra unobscured by the atmosphere, etc. A smaller WAC Corporal rocket was mated to the V-2, forming the two-stage Bumper WAC. The fifth example launched on 24 February 1949 achieved an altitude of 243 miles, a record that was to stand for many years. Payload recovery was not planned because of the high impact velocity anticipated. Therefore all sensor data were telemetered back during the flight. The WAC second stage, the first man-made object to reach the vacuum of space, wasn't found until a year later, quite by accident.

In 1958 the name of the proving grounds was changed to the White Sands Missile Range and in 1961 it became a national range, open to all services and eligible agencies.

Holloman Air Force Base

The V-2 was followed by a host of scientific and military rockets. One of the most successful was the Aerobee, a liquid-propellant rocket with a solid booster. It made its first flight from WSPG on 24 November 1947 and proved to be so inexpensive and reliable that it soon became a standard for high altitude research around the world. An Aerobee launched from the air base at Alamogordo on 16 October 1957 (a week after Sputnik 1)was fitted with an explosive charge that was detonated at an altitude of 53 miles. This scattered its payload of tiny pellets in all directions. Some became billiant meteors as they reentered the Earth's atmosphere, visible as far away as Mt. Palomar in California. Statistically some of the pellets achieved escape velocity to become the first man-made objects to be sent into interplanetary space.

The air base at Alamogordo was established in February 1942 as the Alamogordo Army Air Field and used for B-29 heavy bombardment training. It became the Holloman Air Force Base in 1948 and the home of the Air Force Missile Development Center with a mandate to test various Air Force weapon systems (Snark, Matador, Mace, Hounddog, etc.) and to explore the hazards of travel in near-Earth space. The advent of the jet age had brought with it a new problem; how to survive bail-out at supersonic speeds. Rocket sleds at Holloman on a nearly 10 mile long high speed track have been used to develop ejection seats, capsules and parachutes used on manned craft from the Super Sabre to the Space Shuttle. It was even used to evaluate the stresses on a 1/10th scale Saturn 5 Moon rocket!

On 10 December 1954 Capt. John P. Stapp served as a live subject for one of the most impressive runs made on the track. Simulating a Mach-1 bailout, he was literally blasted up to a speed of 632 mph in five seconds where he was subjected to a wind blast of 1110 lb/ft^2. He was then decelerated to a stop in just 1.4 sec. generating 25 g's in the process. He suffered strap bruises and two black eyes, but he was fine after three days of recovery in the hospital! The track continues to get used for as many as 300 missions per year.

The base's Aeromedical Research Lab has continued Stapp's work with primates. Two of their chimps were selected for tests in the Mercury programme. After extensive

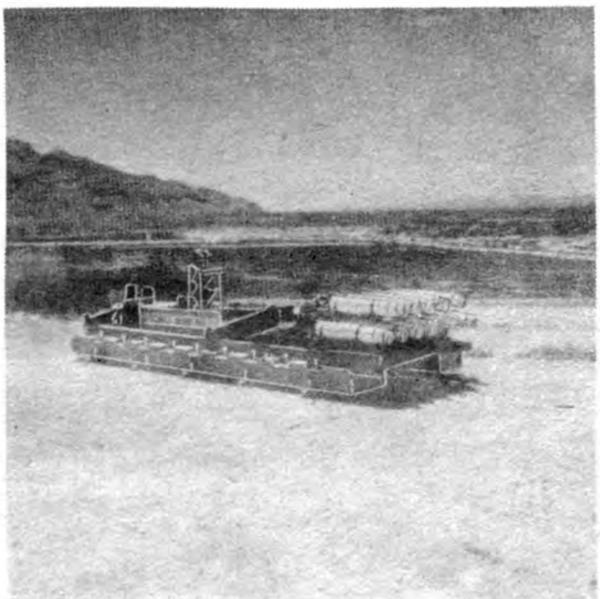


Fig. 5. John Stapp earned the title The Fastest Man on Earth when he rode the Sonic Wind-1 rocket sled to the threshold of the speed of sound in 1954.

training at Holloman, Ham rode a Mercury Redstone on a 155 mile high ballistic flight over the Atlantic on 31 January 1961. Enos followed him on 29 November 1961 on a Mercury Atlas when he made two orbits of the Earth.

Men from Holloman have ventured to the edge of space, not in rockets, but in giant balloons during Project Man-High. Seated securely in a phone-booth sized gondola with its own life-support systems, these men rose nearly 20 miles above the Earth beneath 200 ft. diameter 30 storey tall helium-filled balloons. Capt. David Simon in August 1956 was able to look down at a 70,000 ft. high thunderstorm from 102,000 ft. That was 10,000 ft. higher than weathermen had known thunderstorms to go! During the night, as the helium in his balloon cooled to -95°F he descended perilessly close to the storm. Fortunately the warming rays of dawn brought him back up to a safe altitude. The day and a half that he and others each spent aloft demonstrated man's ability to withstand the isolation of that hostile environment.

The high altitude environmental chamber of Holloman's Central Inertial Guidance Test Facility was used in preparation for these flights. The Apollo spacesuits were also tested there. The CIGTF did extensive testing of guidance systems for the Centaur and the Saturn 5. They also logged over 2,000 hours on the Lunar Module system which was vital to the successful return of the stricken Apollo 13 craft.

White Sands Test Facility

NASA established its own White Sands Test Facility at the western edge of WSMR on 19 December 1962. Here, the Apollo Command/Service and Lunar Module propulsion and RCS systems received their qualification testing. The Apollo Launch Escape System and parachute recovery system was checked out using boiler plate Command Modules on Little Joe-II boosters. The Viking Mars landing system technique was proven at WSTF, the parachute system being qualified using balloon drops over the range, and the engine configured so as not to disturb the Martian soil at touch-down.

The WSTF took on an additional role of materials testing following the Apollo 13 abort. From that has developed a $4 million facility that was among other things responsible for cleaning all the Apollo soil collecting tools and boxes used on the Moon and in the Lunar Receiving Laboratory.

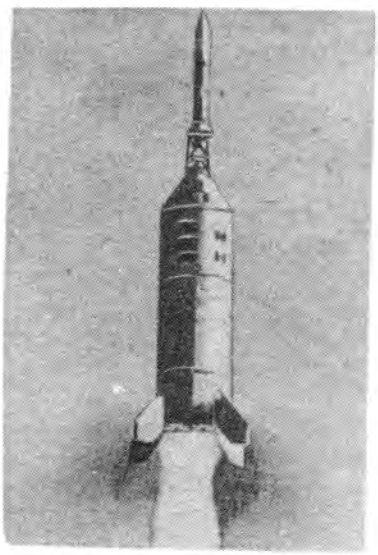


Fig. 6. Boilerplate Apollo Spacecraft-12 rides on a Little Joe-II booster for tests of the Launch Escape System.

Viking proved 1,000 times more difficult; cleaning Viking hardware took nearly two years to complete.

A Museum for the Pioneers of Space

Today WSMR continues to serve the nation as the largest land based missile range in the free world: capable of handling up to 2,000 launches per year. The AFMDC and Aeromedical Research Lab at Holloman were deactivated in 1970 and 1971 respectively. The CIGTF continues to aid in space research, as does NASA's WSTF. But with NASA getting out of the "throw-away" rocket business, most of the area's work is now for the military. To some, this seemed to mark the end of an era; the passing of an age that would never return. If the artifacts and heritage of the region's role in the space programme were ever to be preserved, it would have to be done now.

Dwight Ohlinger, an Alamogordo businessman, was perhaps thinking along those lines back in July 1973 when he conceived the idea of the ISHF. A former Air Force pilot himself, he was aware of how the success of man's progress in space had depended on the contributions of so many; both here and abroad. If what has transpired at WSMR and Holloman, Peenemünde and Baikonur was ever to be fully appreciated, there would have to be some form of recognition for the men and women who had led these programmes: a hall of fame,... a space hall of fame.... an International Space Hall of Fame. As he discussed his ideas with local officials, the project took more concrete form. In addition to an area recognising the pioneers of the space programme, there should be an outdoor rocket park and an exhibit building. Later, perhaps an auditorium and planetarium could be added, to be used by the nearby Alamogordo branch of the New Mexico State University.

With the firm backing of the community, and the governor's office, sufficient funds were raised to commission local architect Charles Nolan, Jr to develop a centre design. Three years and $1.8 million later the finished hall stood ready for dedication on opening day, 5 October 1976.

Nolan had settled on a simple, but impressive design. The Hall would be basically a cube, 60 ft. tall, faced with gold tinted glass panels: 372 in all. This would provide a panoramic view of the surrounding area from each of four floors, but screen out most of the harsh desert Sun. Ramps would be used for travel between floors, creating 'mini-levels' for additional exhibit space. Each floor would be open, permitting rearranging and updating of exhibits as new artifacts were acquired. The primary purpose of the Hall was to honour the pioneers of space exploration. After long and careful deliberation a select committee prepared a list of 35 inductees. They included:

- *Theoreticians*
  - Konstantin Tsiolkovski – (USSR)
  - Walter Hohmann – (Germany)
  - Hermann Oberth – (Rumania-Germany-USA)
  - Eugen Sänger – (Austria)
- *Engineers*
  - Robert Goddard – (USA)
  - Fridrkh Tsander – (USSR)
  - Charles Draper – (USA)
  - Archibald Low – (Great Britain)

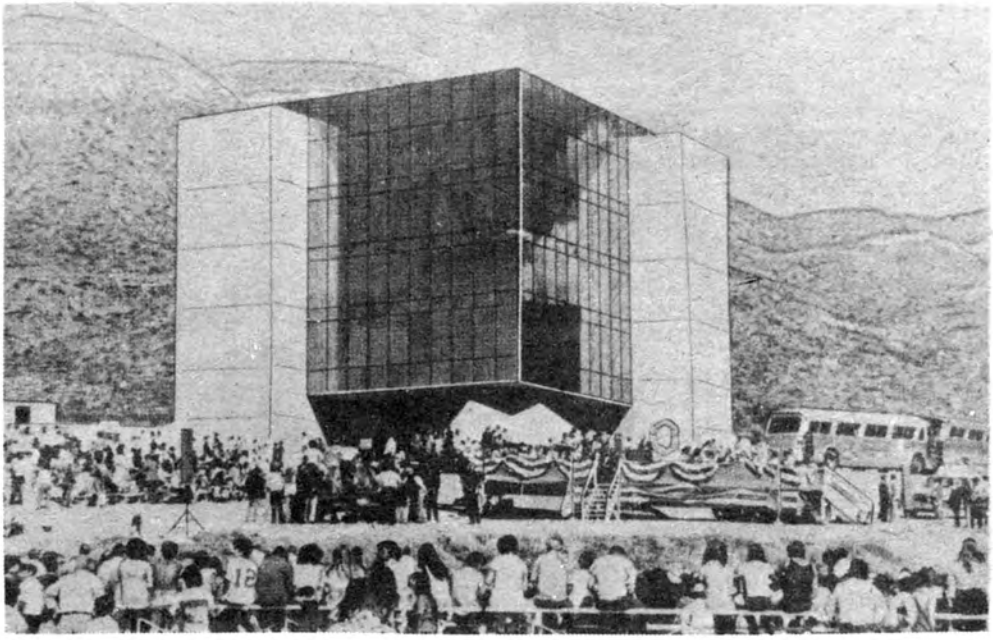


Fig. 7. Dedication Day, 5 October 1976 for the International Space Hall of Fame, shown here against a backdrop of the Sacremento Mountains. In time, additional buildings will be added to eventually form a $10 million complex.

- *Administrators*
  - Wernher von Braun – (Germany-USA)
  - Sergei Korolev – (USSR)
  - Hugh Dryden – (USA)
  - Anatoli Blagonravov – (USSR)

- *Astronauts/Cosmonauts*
  - Yuri Gagarin – (USSR)
  - Aleksei Leonov – (USSR)
  - Neil Armstrong – (USA)

In subsequent years, additional names would be added. Each member is featured with a relief portrait and placard containing a brief biography of his contributions. The Hall is filled with many artifacts as well: scale models of spacecraft and boosters, including a 1/3 scale Vostok built in the Soviet Union and obtained through the aid of Frederick Durant, Assistant Director of the National Air and Space Museum in Washington. There are a number of rocket engines and inertial guidance units, as well as several special exhibits such as Holloman's primate projects featuring Ham's capsule. John Stapp's 'Sonic Wind' that he rode to 632 mph was returned from the Smithsonian, refurbished by the Air Force Systems Command Test Group, and placed on permanent display outside the building; the beginning of a rocket park.

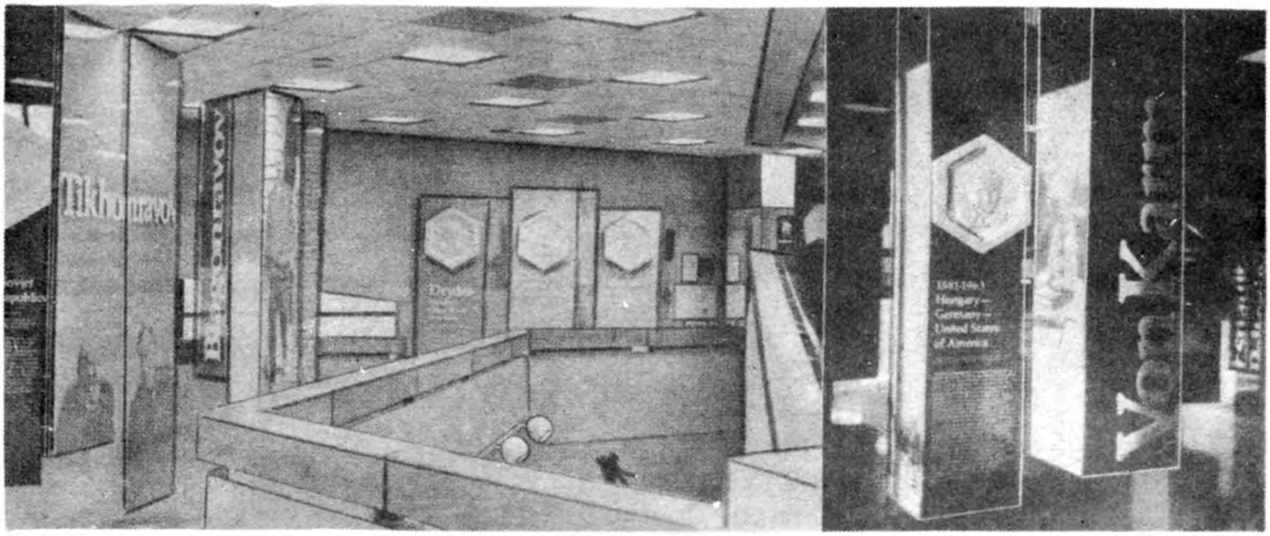
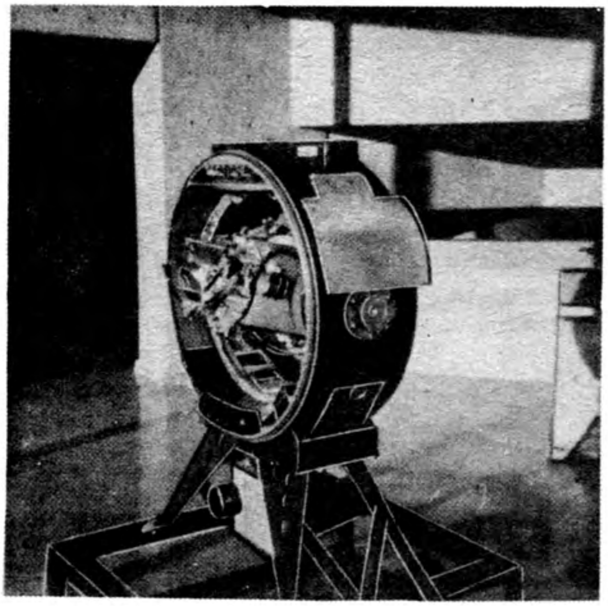


Fig. 8. The ISHF honours the pioneers of space exploration from all over the world. These men and women who have made the dream of space travel a reality are each honoured with a relief portrait and placard containing a brief biography of his or her contributions.



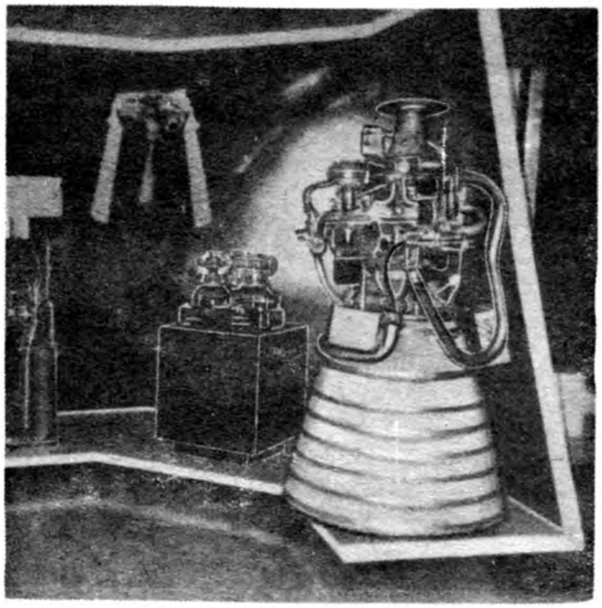


Fig. 9. Exhibits at the ISHF include many items unique to the region. Shown on the left is an inertial guidance unit from a Thor missile that received extensive testing at Holloman's CITGF. The Thor served first as an IRBM and later as the first stage of the Delta booster used to launch hundreds of satellites. Ham's contoured couch that he rode in a sub-orbital Mercury capsule is also on display as part of an exhibit on the primate testing programme that continues today under the direction of the Albany Medical College. Other exhibits feature items from the national space programme. Shown on the right is an engine display with a replica of a Black Betsy four-chamber motor of 6,000 lbf thrust that was used to power the X-1 aircraft that broke the 'sound barrier' in 1947. It was later used on initial flights of the X-15. Next to it is an RL-10 engine used on a number of NASA boosters. Other displays include scale models of Mercury, Gemini, Apollo and Skylab launch vehicles and spacecraft. There is even a Guidance and Navigation Subsystem from an Apollo Command Module. New exhibits are being developed as additional artifacts are acquired.

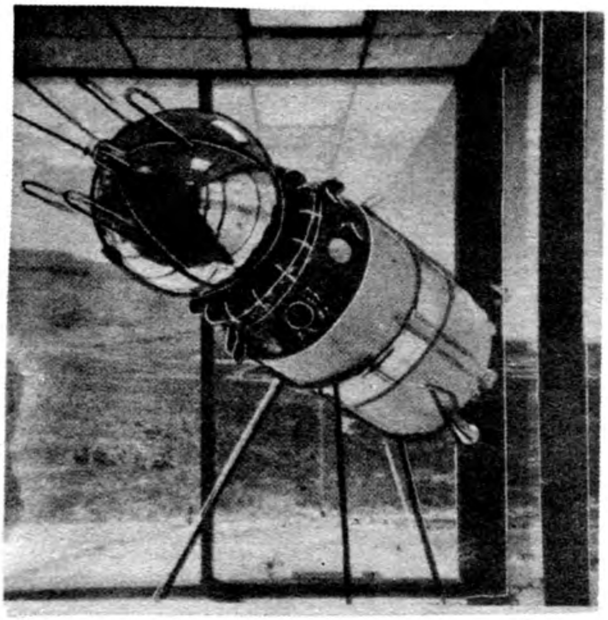


Fig. 10. A one third scale model of the Russian Vostok spacecraft that Yuri Gagarin rode in 1961 to become the first man in space.

Plans for the Future

Today, there are more artifacts outside the building. Two burned-out V-2 tail sections have been placed in a setting, representative of how they would have been found nearly 30 years ago out on the range. A Little Joe-II, left over after the successful completion of Apollo LES qualification tests is there, as well as other Apollo test gear. In time, other rockets will be added. These may include a Viking rocket model (twelve were launched from the WSPG in the early 1950's), a Redstone (the prototype was tested at WSPG), and a number of space boosters since several had their inertial guidance systems qualified at Holloman. Redstone was an important milestone since it was later used as the first stage of Jupiter-C that launched the first U.S. satellite, and later for ballistic tests of the Mercury capsule.

Shortly before the Hall's dedication, Ohlinger, then co-chairman of the Governor's Advisory Group for the ISHF. was asked to reflect back on the past three years progress. "At times, it looked as though it might not get off the ground," he said, But it did, standing at the base of the Sacramento Mountains, above Alamogordo: appearing like a golden cube easily visible 35 miles away. It has been a slow and modest beginning. But in time, it will grow to a $10 million complex; an educational centre of the past, for the future.

"Education is an answer to a lot of things.... especially space," Ohlinger went on to say. "With space, you are dabbling with infinity and an unlimited frontier. We hope that the ISHF will be an invaluable educational asset to the community, state and country in addition to countries all over the world. Space is a 'deep' subject that promotes deep thinking. Future generations may benefit from such facilities.... if they do, then it has all been worth the effort."

ASTRONOMICAL NOTEBOOK

By J. S. Griffith*

SOLAR SYSTEM

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No traces of atmospheric gases have been found for the Jovian satellite and in Ref. 1 infrared spectra of Io obtained with the aid of the 2.24 m telescope at Mauna Kea Observatory, Hawaii, are discussed. Substantial frozen deposits of common volatiles are precluded, and indeed the relatively high mean temperature of the satellite's surface precludes frozen methane and ammonia. In addition no evidence of water ice was found. The candidates for the observed features include carbonates and nitrates in the form of evaporative salts. Sodium nitrate, sodium chloride and sodium carbonate are strong candidates. Volcanic activity in the presence of liquid water may provide the source of nitrogen in saline waters, the evaporation of which yields solid deposits of nitrates.

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[1] Nicholson, P. D., *et al*, 'The rings of Uranus: results of the 10th April 1978 occultation,' *Astron. J.*, **83**, 1240-1248 (1978).
[2] Elliot, J. L., *et al*, *Astron. J.*, **83**, 980 (1978).

STARS

Star Formation

A bright infrared source has been detected within a bright-rimmed dust cloud at the edge of an H II region. It appears to be an early-type star with a circumstellar shell typical of protostars.

In Ref. 1 it is pointed out that one source of external shock pressure that triggers instability in small portions of interstellar clouds leading to star formation is the expansion of H II regions. Carbon monoxide observations of an embedded young early-type star which appears to be the heating source of a bright-rimmed dust cloud in IC 1848 A were undertaken using the 11 m National Radio Astronomy Observatory's antenna. Additional observations using the InSb photometer on the 1.3 m telescope at Kitt Peak National Observatory gave information in the infrared. The situation is that of a young star formed at the interface of an extensive H II region and the surrounding molecular cloud. The bright rimmed dust cloud appears to contain a number of newly-formed stars whose formation was triggered by the expansion of the H II region. The increased external pressure of the expanding H II region started cloud collapse and the B star is seen emerging from the cloud because of its more rapid evolutionary time scale.

[1] Loren, R. B. and Wootten, H. A., 'Star formation in the bright-rimmed molecular cloud IC 1848 A,' *Astrophys. J.* (Letters), **225**. L81-L84 (1978).

Helium Flashes on Neutron Stars

Detailed models of x-ray bursts arising from thermonuclear flashes near the surface of an accreting neutron star are produced.

X-ray bursts are known to have rise times of $\sim$ 1 sec., decay times-scales of 3-30 sec. and be separated by intervals in the range 10^4-10^5 sec. Their total energy is of the order of 10^{39} erg per burst. In Ref. 1 the first detailed models for the production of these flashes in terms of the evolution of the surface layers of a neutron star that is undergoing accretion and nuclear burning are presented.

The ignition of helium transports the photosphere from about 3 m above the burning shell to about 30 m and most of the nuclear energy is lost as black body x-ray radiation with properties remarkably similar to those of observed x-ray bursts. It is expected that the presence of a strong magnetic field will concentrate the accretion to the magnetic polar caps and inhibit nuclear flashes. Neutron stars which display bursts should have moderately low central temperatures, moderately low accretion rates and/or magnetic fields. These characteristics are those of old neutron stars. This may explain why x-ray burst sources are concentrated towards the galactic centre, while most x-ray pulsars (presumed younger neutron stars) are distributed through the disk of the Galaxy.

[1] Joss, P. C., 'Helium burning flashes on an accreting neutron star; a model for x-ray burst sources,' *Astrophys. J.* (Letters), **225**, L123-L127 (1978).

Gravitational Radiation Pursued

A high-precision Weber-type coincidence detector has set the lowest upper limits to the rates of gravitational wave pulses and has now been dismantled. Implications of the null results to the aims of gravitational pulse astronomy are discussed.

The aim of repetitions of Weber's gravitational wave experiments which were started at the Max Planck Institute for Physics and Astrophysics at Munich and the ESRIN Institute in Frascati near Rome were to verify or exclude the

* *Lakehead University, Thunder Bay, Ontario, Canada.*

possibility of existence of gravitational wave pulses of the kind proposed by Weber as an explanation of his own results. In Ref. 1 it is pointed out that though the non-existence at Weber's recorded intensity of such pulses became evident some time ago, the new lower limit set on such pulses have implications for gravitational pulse astronomy. Strong radiation is expected from stellar collapse with weak radiation from close binaries, etc. It is expected that from the collapse of a rotating star, of the order of 1% of a solar mass will go into gravitational radiation around 1 kHz in a bandwidth of 1 kHz. Such radiation would already have been detected if a supernova had occurred from within a distance of about 100 pc. The standard Weber-type experiments do not have the the sensitivity to detect such events from stars near the centre of our Galaxy, but it is hoped that the many new antennae being developed now and during the next decade will provide valuable information on extreme states of matter and final stages of evolution which otherwise would remain shrouded from our view.

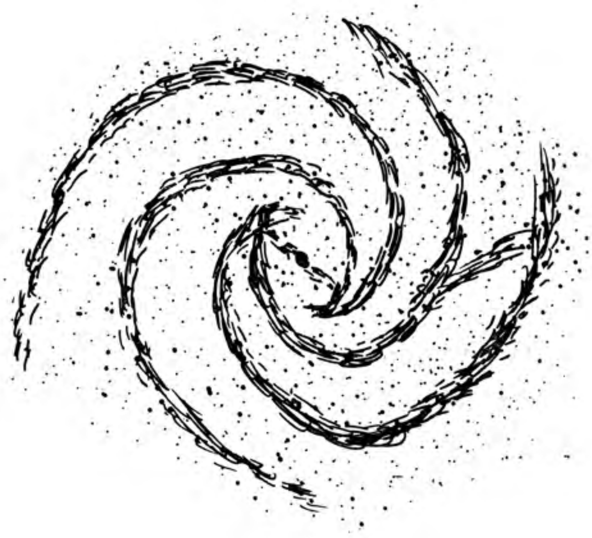
[1] Kafke, P. and Schnupp, L., 'Final results of the Munich-Frascati gravitational radiation experiment,' *Astrophys. J.*, **70**, 97-103 (1978).

GALAXIES

An Outsider's View of our Galaxy

A new model of the Galaxy is constructed with parameters adjusted to fit recent observations. To an outside observer our Galaxy is similar to NGC 6073, 4303, 5921 and 6744 with classification type Sbc.

The model proposed in Ref. 1 is a refinement of previous models based on new data on the brightness distribution and scale length of the galactic bulge. Its Hubble type is probably SAB(rs)bcII, and its absolute magnitude -20. In size its effective diameter is 10 kpc and isophotal diameter 23 kpc. A combination of the model features and the distribution of H II regions leads to a picture of our Galaxy as in the figure. Earlier representation of our Galaxy with a complicated multiarm structure are now considered to be misrepresentations caused by a confusion between distance and velocity differences. The present model has a weak bar and a partial inner ring of diameter 6 kpc.



Model of the Galaxy based on new observational data.

[1] de Vaucouleurs, G. and Pence, W. D., 'An outsider's view of the Galaxy: photometric parameters, scale lengths, and absolute magnitudes of the spheroidal and disk components of our Galaxy,' *Astron. J.*, 83, 1163-1173 (1978).

Halo Clusters and the Galactic Halo

One hundred and seventy-seven red giants in 19 globular clusters were observed with the multichannel spectrometer of the Hale 5 m reflector on Palomar Mountain. The spectral flux density of each star was measured in 22 bands. Most of the clusters were over 8 kpc from the galactic centre. There is no detectable change in chemical abundance with distance, and this feature, combined with others, leads to the hypothesis that the loosely bound clusters of the outer halo have a broader range of age than the more tightly bound clusters and originated in transient protogalactic fragments that continued to fall into dynamical equilibrium with the Galaxy for some time after the collapse of its central regions had been completed.

In Ref. 1 it is pointed out that if the metal-poor clusters formed from material that was freely falling during the galactic collapse there should be some distance beyond which the abundance gradient ceases. Individual red giants were chosen as a source of information on abundances, as they may be observed in even the more distant clusters.

The globular clusters are distributed with an approximately spherical symmetry about the galactic centre. The most metal-rich clusters are not concentrated in the galactic plane, but globular clusters with metal abundances greater than one-tenth of the solar abundance are confined to a region within 8 kpc of the galactic centre – the inner halo. Outside the inner halo the distribution over abundance of halo globular clusters is independent of galactocentric distance. For the system of halo clusters, which are among the oldest objects making up the Galaxy, their properties are clues to the processes involved in the formation of the Galaxy. The clusters which now constitute the outer halo may have formed from freely falling gas or in a number of small protogalaxies that subsequently merged to form the present galactic halo. The first idea is inconsistent with the deduced spread in ages of the clusters, which appears to be longer than the dynamical time scale.

A more chaotic picture for the origin of the Galaxy than that of an isolated, uniform, homogeneous, collapsing protogalaxy is found. The gas from which the clusters and stars of the outer halo formed continued to fall into the Galaxy for some time after the collapse of the central regions had been completed. Interactions of the infalling gas dissipated much of its kinetic energy and gave rise to transient high-density regions in which the halo stars and clusters formed, with these regions dispersing as they underwent chemical evolution. The stars and clusters that had formed within them eventually fell into dynamical equilibrium with the Galaxy and make up its present outer halo while the gas lost from these protogalactic star-forming regions was eventually swept into the galactic disk.

[1] Searle, L. and Zinn, R., 'Compositions of halo clusters and the formation of the galactic halo,' *Astrophys. J.*, **225**, 357-379 (1978).

Andromeda

During a sounding rocket flight far-ultraviolet images of the Andromeda galaxy were obtained. Extended ultraviolet sources in M31 (Andromeda) were found. The source centred on the nucleus is extended in the direction of the major axis of the galaxy and it appears that in M31 the ultraviolet radiation in the nuclear regions is due to young early-

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The nine rings are the same as those described in Ref. 2 and no additional rings were observed. The most prominent rings, in order of distance from Uranus, are α, β, γ, δ, ϵ, with η between β and γ and 4, 5, 6 just inside α. Rings η, γ and δ are coplanar and circular; 4, α, β have measurable eccentricities while 5 and 6 have an undetermined structure. Rings α, γ and δ are rather opaque with widths $\sim$ 2-5 km. The β ring was clearly resolved with an optical depth $\sim$ 0.5 and a width $\sim$ 5 km. The outermost ϵ ring appears to be a continuous non-circular ring with sharp edges in the form of a precessing keplerian ellipse (a $\sim$ 44840 km), leading to a value of J_2 for Uranus of 3.43×10^{-3}.

[1] Nicholson, P. D., *et al*, 'The rings of Uranus: results of the 10th April 1978 occultation,' *Astron. J.*, **83**, 1240-1248 (1978).
[2] Elliot, J. L., *et al*, *Astron. J.*, **83**, 980 (1978).

STARS

Star Formation

A bright infrared source has been detected within a bright-rimmed dust cloud at the edge of an H II region. It appears to be an early-type star with a circumstellar shell typical of protostars.

In Ref. 1 it is pointed out that one source of external shock pressure that triggers instability in small portions of interstellar clouds leading to star formation is the expansion of H II regions. Carbon monoxide observations of an embedded young early-type star which appears to be the heating source of a bright-rimmed dust cloud in IC 1848 A were undertaken using the 11 m National Radio Astronomy Observatory's antenna. Additional observations using the InSb photometer on the 1.3 m telescope at Kitt Peak National Observatory gave information in the infrared. The situation is that of a young star formed at the interface of an extensive H II region and the surrounding molecular cloud. The bright rimmed dust cloud appears to contain a number of newly-formed stars whose formation was triggered by the expansion of the H II region. The increased external pressure of the expanding H II region started cloud collapse and the B star is seen emerging from the cloud because of its more rapid evolutionary time scale.

[1] Loren, R. B. and Wootten, H. A., 'Star formation in the bright-rimmed molecular cloud IC 1848 A,' *Astrophys. J.* (Letters), **225**. L81-L84 (1978).

Helium Flashes on Neutron Stars

Detailed models of x-ray bursts arising from thermonuclear flashes near the surface of an accreting neutron star are produced.

X-ray bursts are known to have rise times of $\sim$ 1 sec., decay times-scales of 3-30 sec. and be separated by intervals in the range 10^4-10^5 sec. Their total energy is of the order of 10^{39} erg per burst. In Ref. 1 the first detailed models for the production of these flashes in terms of the evolution of the surface layers of a neutron star that is undergoing accretion and nuclear burning are presented.

The ignition of helium transports the photosphere from about 3 m above the burning shell to about 30 m and most of the nuclear energy is lost as black body x-ray radiation with properties remarkably similar to those of observed x-ray bursts. It is expected that the presence of a strong magnetic field will concentrate the accretion to the magnetic polar caps and inhibit nuclear flashes. Neutron stars which display bursts should have moderately low central temperatures, moderately low accretion rates and/or magnetic fields. These characteristics are those of old neutron stars. This may explain why x-ray burst sources are concentrated towards the galactic centre, while most x-ray pulsars (presumed younger neutron stars) are distributed through the disk of the Galaxy.

[1] Joss, P. C., 'Helium burning flashes on an accreting neutron star; a model for x-ray burst sources,' *Astrophys. J.* (Letters), **225**, L123-L127 (1978).

Gravitational Radiation Pursued

A high-precision Weber-type coincidence detector has set the lowest upper limits to the rates of gravitational wave pulses and has now been dismantled. Implications of the null results to the aims of gravitational pulse astronomy are discussed.

The aim of repetitions of Weber's gravitational wave experiments which were started at the Max Planck Institute for Physics and Astrophysics at Munich and the ESRIN Institute in Frascati near Rome were to verify or exclude the

* *Lakehead University, Thunder Bay, Ontario, Canada.*

possibility of existence of gravitational wave pulses of the kind proposed by Weber as an explanation of his own results. In Ref. 1 it is pointed out that though the non-existence at Weber's recorded intensity of such pulses became evident some time ago, the new lower limit set on such pulses have implications for gravitational pulse astronomy. Strong radiation is expected from stellar collapse with weak radiation from close binaries, etc. If is expected that from the collapse of a rotating star, of the order of 1% of a solar mass will go into gravitational radiation around 1 kHz in a bandwidth of 1 kHz. Such radiation would already have been detected if a supernova had occurred from within a distance of about 100 pc. The standard Weber-type experiments do not have the the sensitivity to detect such events from stars near the centre of our Galaxy, but it is hoped that the many new antennae being developed now and during the next decade will provide valuable information on extreme states of matter and final stages of evolution which otherwise would remain shrouded from our view.

[1] Kafke, P. and Schnupp, L., 'Final results of the Munich-Frascati gravitational radiation experiment,' *Astrophys. J.*, **70**, 97-103 (1978).

GALAXIES

An Outsider's View of our Galaxy

A new model of the Galaxy is constructed with parameters adjusted to fit recent observations. To an outside observer our Galaxy is similar to NGC 6073, 4303, 5921 and 6744 with classification type Sbc.

The model proposed in Ref. 1 is a refinement of previous models based on new data on the brightness distribution and scale length of the galactic bulge. Its Hubble type is probably SAB(rs)bcII, and its absolute magnitude -20. In size its effective diameter is 10 kpc and isophotal diameter 23 kpc. A combination of the model features and the distribution of H II regions leads to a picture of our Galaxy as in the figure. Earlier representation of our Galaxy with a complicated multiarm structure are now considered to be misrepresentations caused by a confusion between distance and velocity differences. The present model has a weak bar and a partial inner ring of diameter 6 kpc.

Model of the Galaxy based on new observational data.

[1] de Vaucouleurs, G. and Pence, W. D., 'An outsider's view of the Galaxy: photometric parameters, scale lengths, and absolute magnitudes of the spheroidal and disk components of our Galaxy,' *Astron. J.*, **83**, 1163-1173 (1978).

Halo Clusters and the Galactic Halo

One hundred and seventy-seven red giants in 19 globular clusters were observed with the multichannel spectrometer of the Hale 5 m reflector on Palomar Mountain. The spectral flux density of each star was measured in 22 bands. Most of the clusters were over 8 kpc from the galactic centre. There is no detectable change in chemical abundance with distance, and this feature, combined with others, leads to the hypothesis that the loosely bound clusters of the outer halo have a broader range of age than the more tightly bound clusters and originated in transient protogalactic fragments that continued to fall into dynamical equilibrium with the Galaxy for some time after the collapse of its central regions had been completed.

In Ref. 1 it is pointed out that if the metal-poor clusters formed from material that was freely falling during the galactic collapse there should be some distance beyond which the abundance gradient ceases. Individual red giants were chosen as a source of information on abundances, as they may be observed in even the more distant clusters.

The globular clusters are distributed with an approximately spherical symmetry about the galactic centre. The most metal-rich clusters are not concentrated in the galactic plane, but globular clusters with metal abundances greater than one-tenth of the solar abundance are confined to a region within 8 kpc of the galactic centre – the inner halo. Outside the inner halo the distribution over abundance of halo globular clusters is independent of galactocentric distance. For the system of halo clusters, which are among the oldest objects making up the Galaxy, their properties are clues to the processes involved in the formation of the Galaxy. The clusters which now constitute the outer halo may have formed from freely falling gas or in a number of small protogalaxies that subsequently merged to form the present galactic halo. The first idea is inconsistent with the deduced spread in ages of the clusters, which appears to be longer than the dynamical time scale.

A more chaotic picture for the origin of the Galaxy than that of an isolated, uniform, homogeneous, collapsing protogalaxy is found. The gas from which the clusters and stars of the outer halo formed continued to fall into the Galaxy for some time after the collapse of the central regions had been completed. Interactions of the infalling gas dissipated much of its kinetic energy and gave rise to transient high-density regions in which the halo stars and clusters formed, with these regions dispersing as they underwent chemical evolution. The stars and clusters that had formed within them eventually fell into dynamical equilibrium with the Galaxy and make up its present outer halo while the gas lost from these protogalactic star-forming regions was eventually swept into the galactic disk.

[1] Searle, L. and Zinn, R., 'Compositions of halo clusters and the formation of the galactic halo,' *Astrophys. J.*, **225**, 357-379 (1978).

Andromeda

During a sounding rocket flight far-ultraviolet images of the Andromeda galaxy were obtained. Extended ultraviolet sources in M31 (Andromeda) were found. The source centred on the nucleus is extended in the direction of the major axis of the galaxy and it appears that in M31 the ultraviolet radiation in the nuclear regions is due to young early-

type stars in or near the equatorial plane of the galaxy rather than to radiation from a nonthermal point source or highly evolved stars.

The authors of Ref. 1 used an electrographic Schmidt camera flown on an Aerobee 200 rocket from White Sands Missile Range on 29 October 1976. It is known that ultraviolet radiation emanates from nuclear regions of galaxies, and three explanations have been proposed. Hot highly evolved stars, like those at the centres of planetary nebulae and hot white dwarfs, would be expected to be distributed like the old stellar populations, with ultraviolet isophotes similar to visible isophotes. Hot, young main-sequence stars would give rise to ultraviolet isophotes with greater eccentricities than the visible ones. Nonthermal violent activity in the nucleus would give a highly condensed, star-like source. The observations reported give isophotes indicating a source consisting of early-type stars close to the galactic plane, with strong evidence against a nonthermal point source at the galactic centre.

[1] Carruthers, G. R., Heckathorn, H. M. and Opal, C. B., 'Rocket ultraviolet imagery of the Andromeda galaxy,' *Astrophys. J.*, **225**, 346-356 (1978).

QUASARS

Radio Observations of Quasars

Radio observations with the Green Bank (West Virginia) interferometer at 2695 MHz are reported which all confirm the picture of a compact central component and two outer lobes.

There is a close connection [1] between the central component and the quasar optical continuum emission. Most optically discovered quasars seem to have little or no radio emission, without a central source or large-scale extended lobes. The infrared and millimetre continuum spectra of bright radio quiet quasars need to be studied.

In Ref. 2 optical identifications of flat spectra sources with the bouńdaries of precise radio-optical coincidence are reported.

[1] Owen, F. N., Porcas, R. W. and Neff, S. G., 'Interferometer observations of quasars from the Jodrell Bank, 966-MHz survey,' *Astron. J.*, **83**, 1009-1020 (1978).

[2] Condon, J. J., Jauncey, D. C. and Wright, A. E., 'Optical identification of a complete sample of flat-spectrum radio sources,' *Astron. J.*, **83**, 1036-1046 (1978).

THE COSMIC BLACKBODY RADIATION: A POTENTIAL GUIDE TO INTERSTELLAR SIGNAL BEACONS?

By Robert Sheaffer

Introduction

It is a common assumption among SETI theorists that intelligent civilizations wishing to establish radio communication with other worlds will utilize narrow-bandwidth signals on one, or at most a relative few, wavelengths which are in some way related to one of the prominent radio emission lines of interstellar matter. Dixon [1] proposes the principle of *anti-cryptography*: that, in order to make its signals as easy as possible to detect, each transmitting civilization generates a very narrow-bandwidth omnidirectional signal at the precise wavelength of one of the major interstellar lines (Dixon argues that it will be hydrogen). All other things being equal, the narrower the bandwidth, the farther the signal can be detected, but a longer time is required to scan a given region of the radio spectrum. If, however, the wavelength is precisely known, there is no reason for not making the bandwidth extremely narrow.

There is at present no general consensus concerning which emission line is to be used, or whether a harmonic of that wavelength, rather than the wavelength itself, is to be used. Among the reference lines most frequently suggested for SETI use are: 1.42 GHz (21 cm) hydrogen; 22 GHz (1.35 cm) water; and the 1.662 GHz (18 cm) hydroxyl radical, which together with hydrogen, the other component of water, defines the region of the radio spectrum known as the "water hole."

Some researchers argue that the 21-cm hydrogen line represents the 'natural' wavelength for a signalling beacon, since it is the most prominent of the interstellar lines. Others argue for the use of one or a few other lines, or their harmonics. If this type of reasoning is correct, we have at best a single precisely-defined wavelength to search for the existence of a signalling beacon, and at worst we have perhaps a dozen such wavelengths. While one should not understate the magnitude of an exhaustive all-sky search of even a single precisely known wavelength, the SETI problem would become hopelessly impossible if we had to search for a beacon arbitrarily positioned in the infinitude of the radio spectrum.

But even if a single wavelength is to be adopted – let us assume for discussion that it is to be the 21-cm hydrogen line – even this is not sufficiently precise to permit us to apply the principle of anti-cryptography, because the relative motions of the transmitting and receiving planets introduces significant Doppler changes in the apparent wavelengths. The Earth's orbital velocity of 29 km/sec introduces a shift of up to 137 kHz in the perceived wavelength of a precise 21-cm transmission. Since we are looking for a signal of very narrow bandwidth, the Doppler shift poses a significant problem. The Solar System's motion of 19 km/sec with respect to the nearby stars introduces additional changes in wavelength.

Problems of Relative Motions

The motions of the receiving planet are not the only ones with which we must contend. Since typical stellar velocities in our vicinity are anywhere from 15 to 65 km/sec, with more than a few above 200 km/sec, equally great uncertainties are introduced by the proper motion of the Solar System of the transmitting planet, as well as by the planet's orbital

and rotational velocities. Following Dixon's principle of anti-cryptography, we can make full adjustment for all known motions of our planet and Solar System. This is in fact being done in the Ohio State SETI programme. However, there is no *a priori* way that we can know anything about the motions of the transmitting planet. Those doing the transmitting could, of course, make the same adjustments for their motion, if some common standard of rest were to suggest itself. But unless we can define a 'natural' standard of rest, easily and precisely deducible by the civilizations on both the receiving and transmitting planets, there is no way that a unique and unambiguous apparent wavelength for the 21-cm hydrogen line can be defined.

Dixon [1] adopts the centre of the Milky Way Galaxy as a standard of rest. This has the advantage of providing a "natural" reference frame for all inhabitants of our Galaxy, one which can, in principle, easily be deduced by all. There are, however, problems with the use of the galactic standard of rest. There is currently an uncertainty of about ± 25 km/sec in our determination of the Earth's galactic velocity, corresponding to an uncertainty in frequency as great as 125 kHz. Also, since this is a galactic standard, it is of no value in establishing a reference frame for extragalactic signal beacons.

There may be, however, a far more "natural" and universal standard of rest. Recent studies have detected small directional anisotropies in the 3°K cosmic blackbody radiation, the remnant of the primordial fireball in which the Universe was created [2, 3, 4]. The anisotrophy appears to be perfectly regular, varying according to the cosine of the angle between the point under observation and the point of greatest intensity [2]. Unless we postulate a peculiar intrinsic anisotropy to the radiation itself, the conclusion appears inescapable that the anisotrophy is due to the motion of the Earth. Thus the cosmic blackbody radiation appears to define a sort of "absolute motion" of the Earth, a concept which seems counter-intuitive when viewed in the light of relativity theory. Cosmologist P. J. E. Peebles has satirically termed this finding the "new aether drift."

Universal Standard of Rest

This "absolute motion" also implies the existence of a *universal* standard of rest, i.e., *that frame of reference in which the cosmic blackbody radiation would appear completely isotropic*. It is hereby suggested that the universal standard of rest, which apparently is defined by the cosmic blackbody radiation, provides a far more "natural," and certainly more universal, reference frame for Doppler corrections than any reference frame based upon local parameters. The universal standard of rest is readily determinable from any planet in any region of the Universe.

The research of Smoot, Gorenstein and Muller [2] suggests that Earth has an "absolute motion" of 390 ± 60 km/sec in the direction 11 h ± 0.6 R.A., 6° ± 10° dec (along the southern boundary of the constellation Leo). The Milky Way Galaxy itself appears to have a velocity of 603 km/sec with respect to the universal standard of rest, in the direction 10.4 h R.A., -18° dec. While the current uncertainty in the Earth's "absolute motion" of ± 60 km/sec is approximately 2½ times greater than the uncertainty in the galactic standard of rest, measurements of the cosmic blackbody anisotopy are still in their infancy. Much of the weak cosmic blackbody radiation lies at wavelengths where radio noise from the atmosphere is a significant factor, necessitating the use of high-altitude balloons or aircraft to make the measurements. Interference from galactic emissions also poses a problem. A space-based receiver system, observing in the centimetre wavelength range, could in principle make a far more accurate determination of the universal standard of rest.

Proposals

To apply the recent findings on the cosmic blackbody radiation to SETI research, two proposals seem in order: 1. that feasibility studies be undertaken for a space-based system to make the most accurate measurements possible of the cosmic blackbody radiation, and 2. that as soon as reasonably accurate measurements are available defining the universal standard of rest (if such it indeed be), that SETI observations be made at the wavelengths of the principal interstellar lines, with Doppler corrections made according to this reference frame. It may be that the hypothetical "Galactic Club" of communicating civilizations uses the radio remnant of the big bang to define a universal reference frame, which can lead us to the beacons it has set up to attract new members!

REFERENCES

1. Dixon, Robert S., "A Search Strategy for Finding Extraterrestrial Radio Beacons," *Icarus*, **20**, 187-199 (1973).
2. Smoot, Gorenstein and Muller, "Detection of Anisotropy in the Cosmic Blackbody Radiation," *Physical Review Letters*, **39**, 14 (1977).
3. Corey and Wilkinson, *Bull. Astron. Astrophys. Soc.*, **8**, 351 (1976).
4. Muehlner and Weiss, *Infrared and Submillimeter Astronomy*, Astrophysics and Space Sciences Library (Reidel, Hingham, Mass., 1963) Vol. 63.

SECOND HIGH ENERGY ASTRONOMY OBSERVATORY

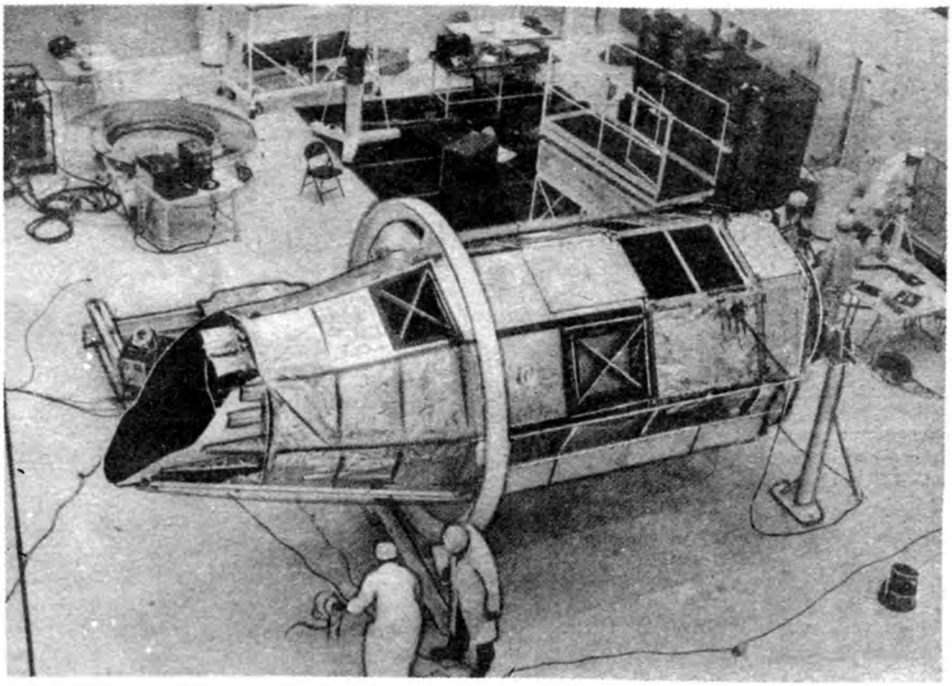
NASA launched its second High Energy Astronomy Observatory (HEAO) from the Kennedy Space Center on 13 November 1978, continuing a three-mission programme to study some of the most intriguing mysteries of the Universe – pulsars, quasars, exploding galaxies and black holes in space.

Carrying a focusing X-ray telescope and a variety of sensitive instruments, HEAO 2 can manoeuvre and point for long periods of time at selected X-ray sources already identified by its predecessor, HEAO 1 (see *Spaceflight*, July-August 1977, pp. 271-274).

HEAO 1 was launched to conduct a general X-ray sky survey, and HEAO 3 will be launched this year to collect celestial gamma ray and cosmic ray data. These high-energy rays cannot be studied through Earth-based telescopes because of the obscuring effects of our atmosphere. The rays were observed initially by instruments on sounding rockets and balloons, and by small satellites which did not have the instrumentation capabilities required for high data resolution and sensitivity. These capabilities are now available in the HEAO satellite.

The "pictures" returned by HEAO 2 are the first space-

Second High Energy Astronomy Observatory



HEAO 2 seen here during check out at the Kennedy Space Center was built by TRW for NASA's Marshall Space Flight Center. Satellites of the HEAO family are the heaviest unmanned Earth-orbiting satellites designed to perform general sky survey, mapping X-ray sources throughout the celestial sphere and also measuring low-energy gamma-ray flux.

National Aeronautics and Space Administration

craft-generated X-ray images of wide objects other than the Sun. (The Apollo Telescope Mount, which was part of Skylab, produced images of the Sun in the X-ray region). HEAO 2's images, acquired by the X-ray telescope, are converted to telemetry, then received and taped by ground stations. Eventually this telemetry will be reconstructed as photographs showing size, structure and detail of the objects viewed by HEAO.

Information returned by HEAO may provide clues to the nature of some of the "newest" and most mysterious celestial objects in the Universe. This knowledge, in turn, could lead to a better understanding of the invisible high-energy Universe and to new theories about energy production and high-density nuclear matter.

The first observatory is still operational, surveying and mapping X-ray sources throughout the celestial sphere and also measuring the low-energy gamma ray flux. The spacecraft can survey the entire sky in six months. Although HEAO 1 was designed for only a six-month lifetime, the quality of the data return was so excellent that an extension was authorised. The spacecraft is expected to remain active until it re-enters Earth's atmosphere or depletes the onboard control gas supply, probably in early or mid-1979. Besides mapping the X-ray sky, the highly successful satellite has performed more than 300 pointing operations.

- HEAO 1 scientific results indicate that the map of X-ray sources will contain up to 1,500 sources when all data have been analysed. This number would increase the previously known number of X-ray sources by a factor of four.

- A map of the diffuse celestial X-ray background has been completed. There is strong evidence that a major contributor to this background is a hot universal gas which may constitute a significant fraction of the mass of the Universe. Another large component of universal matter has been detected by HEAO in the form of gas enveloping clusters of galaxies.

- Precise positions (within 10 arc seconds or better) have been developed for about 140 X-ray sources. The precise positions have enabled ground-based astronomers to locate many of these as faint visible objects.

HEAO 1 and HEAO 3 are designated as scanning (or mapping) missions. They rotate slowly end-over-end, with one revolution about every 30 minutes. Each uses a gas thrust reaction control system to maintain proper sky-scanning orientation so that the solar arrays face the Sun at all times to provide electrical power for the satellite.

HEAO 2 is different. It must point to specific stars or points in the sky, so reaction wheels that control torque are installed to provide a precise and highly accurate pointing capability of one arc minute or better for the longer planned mission. HEAO 2 is termed a celestial pointing mission.

HEAO 2 has a designed mission lifetime of one year for pointing at selected X-ray sources. HEAO 3's mission will be six months long.

All three observatories are designed to be placed in low circular orbits, about 455 to 540 kilometres (280 to 335 miles) above Earth. The altitude is far enough above the atmosphere to detect radiation which generally cannot reach the ground.

X-rays and gamma rays are composed of photons, which are particles having energy but no mass, as in light rays. Cosmic rays are composed of particles such as electrons, protons and atomic nuclei which have both mass and energy. An X-ray has thousands of times the energy of ordinary light, and gamma rays have millions of times the energy of visible light.

The high-energy X-rays and gamma rays which the HEAOs study travel through space at the speed of light. They are forms of electromagnetic radiation. Other forms include ultraviolet and infrared radiation.

For many years researchers have studied these forms of radiation and their energy mechanisms and have transformed them into many practical uses, including electrical applications, holography, radio and television, radar and infrared photography.

In high-energy astronomy, interest is in the extreme short-length waves known as X-rays and gamma rays. These rays are produced on Earth by natural radioactive minerals and manmade processes. X-rays and gamma rays on Earth are produced from well-understood physical processes and are used routinely in physics, chemistry, engineering, medical

FIRST PICTURE OF AN X-RAY STAR was transmitted recently from the second High Energy Astronomy Observatory. The subject is Cygnus X-1, a binary system located some 6,000 light years from Earth and believed to contain a 'black hole.' In the photograph the dots represent X-rays. A computer has reconstructed the image, substituting light spots for X-rays. The raw data includes scattered background radiation from other sources; only the small white central portion represents the X-ray counts received from the star itself.

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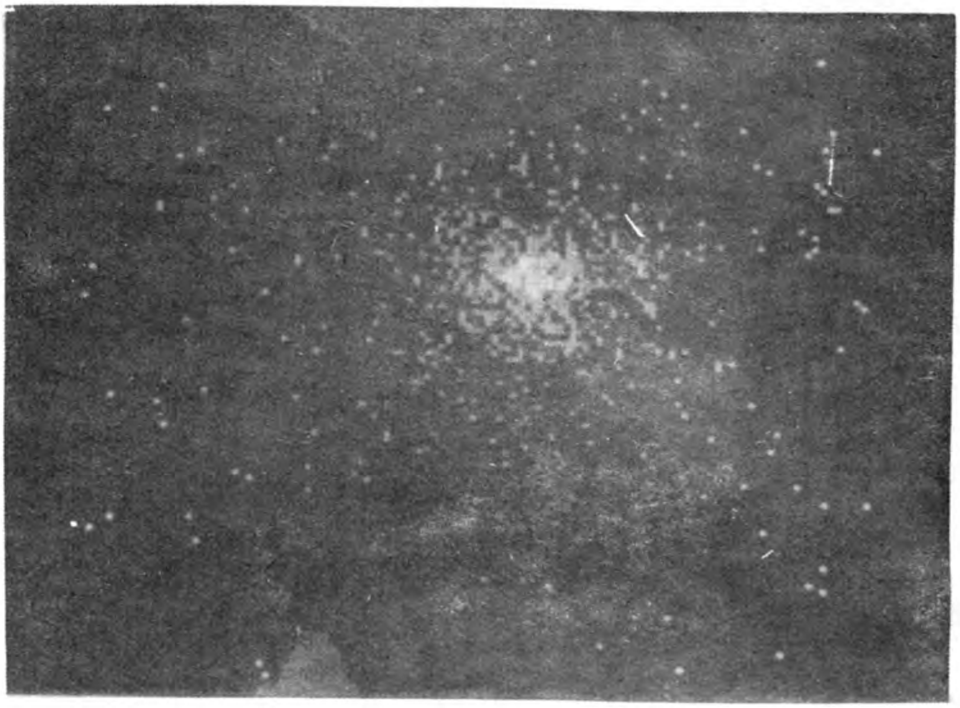


Table 1. HEAO 1 Science Results

- Over 130 sources of X-ray radiation have been identified from data analysed thus far for one ninth of the sky. Many of these were previously undetected. (Many sources have been located with high precision, allowing astronomers to search for visible counterparts).

- HEAO 1 has returned the highest quality spectral and temporal data yet obtained on neutron stars, and a black hole possibility has been identified near Constellation Scorpius, bringing the total to four. (Others: Cygnus X-1, Circinus X-1, and Hercules X-1). Also, significant new measurements have been made on neutron stars regarding magnetic fields and dynamics.

- Previously undetected hot thermal plasma has been discovered. The plasma, distributed throughout space, may constitute the bulk of the mass of the Universe. This may help answer the question of whether the Universe will continue to expand forever or eventually start contracting.

- Extreme variability has been discovered in the X-ray energy band of objects such as quasars (which produce over one thousand million times the luminosity of the Sun, but may be no larger than the Solar System.

- X-ray data have been obtained from the vicinity of two quasars about eight thousand million light years distant – more than half way to the outer edge of the Universe.

- Pronounced soft X-ray emission has been detected for the first time from cataclysmic variable stars (novae, which exhibit extreme flaring, but not supernovae).

- Coronas of normal stars like our Sun have been detected in the X-ray band.

- Strong X-ray emission has been detected, apparently from very hot stellar winds from certain types of stars.

- A massive quantity of gas enveloping two clusters of galaxies has been detected, indicating that sufficient mass may exist in all such systems to convince scientists that the Universe is "closed."

Table 2. HEAO Spacecraft and Observatory

The basic subsystems design of the HEAO spacecraft is common for all three missions. The shape, arrangement and objectives of the experiments on the three spacecraft are different.

The observatories (i.e., spacecraft plus experiments) each weigh about 3,150 kg (7,000 lb), including 1,350 kg (3,000 lb) of experiments. Overall observatory length is 5.8 metres (19 ft).

The HEAO spacecraft subsystems take advantage of existing hardware designs developed in other spacecraft programmes. About 80 per cent of HEAO hardware designs are "off-the-shelf."

The HEAO 2 experiment module structure is octagonal, and combines simplicity with maximum rigidity and focal length in support of the X-ray telescope.

HEAO 2 mission requirements are met through simple modifications to the HEAO 1 design. For example, the HEAO 2 pointing and stability requirements are met by placing a reaction wheel system in an empty area of the equipment module. The extra electrical power required to drive the wheels is produced by increasing the size of the solar array.

Continued from page 157]

and other scientific fields.

Much is yet to be learned, however, about the way in which X-rays and gamma rays are produced in deep space – in some cases, with incredible intensity.

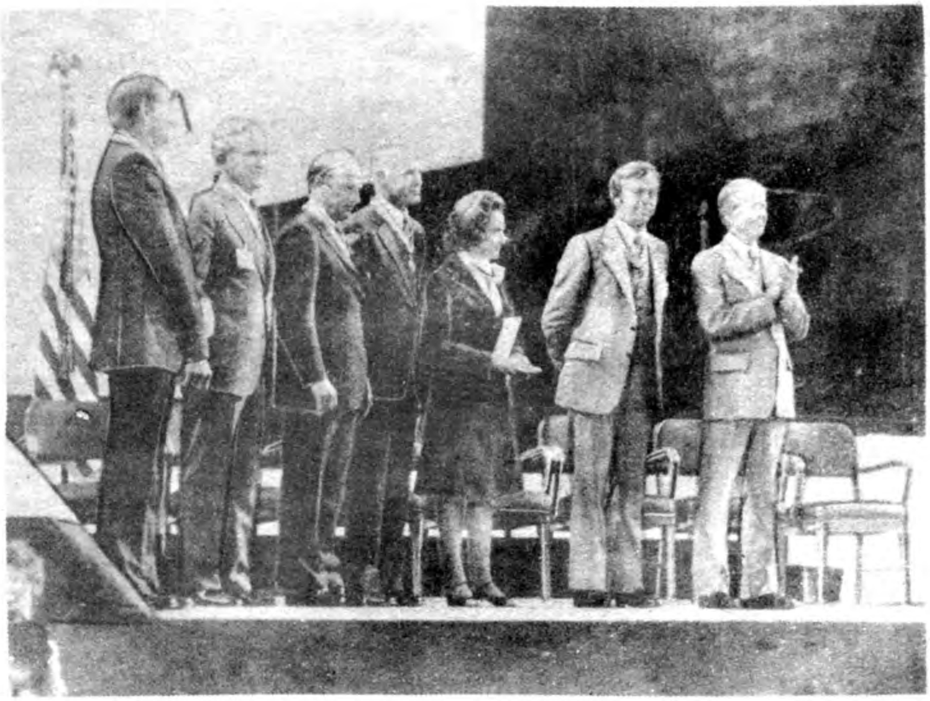
It is expected that the radiation data collected by the HEAO observatories, after being reduced and analysed, will lead to a better understanding of how the extremely high energies are generated in space, how basic elements are formed, how the Universe evolved and the extreme physical processes evident within the Universe.

Several hypotheses are being pursued in astrophysics and cosmology that need additional experimental evidence which may be obtained by HEAO. These hypotheses are related to radio galaxies, neutron stars, pulsars, quasars, star explosions and supernovae, many of which radiate copiously in the X-ray and gamma ray part of the spectrum.

WHERE ARE THEY NOW?

By David J. Shayler

Part 5



PRESIDENT CARTER applauds after awarding the Congressional Space Medal of Honor to six former astronauts at the Kennedy Space Center on the occasion of NASA's 20th Anniversary on 1 October 1978. Medal recipients are, left to right, Neil Armstrong, the first man to walk on the Moon; Frank Borman, Commander of the first manned spacecraft to orbit the Moon: Charles Conrad Jr., Commander of the second lunar landing and of the first crew to occupy the Skylab space station; John H. Glenn, Jr., the first American to orbit the Earth; Virgil I. Grissom (posthumously), the second American in space and a major contributor to the Mercury, Gemini and Apollo programmes; and Alan B. Shepard, the first American in space. The late Virgil Grissom's medal was received by his wife, Betty.

National Aeronautics and Space Administration

Astronaut Statistics

On 5 May, 1961 Alan B. Shepard became the first American to fly in space onboard Mercury-Redstone 3. Since that date, nearly eighteen years ago, a total of 42 other American astronauts have flown a further 30 missions in space. Of these, 9 missions were to the Moon between December 1968 and December 1972; they resulted in six manned landings, the first being Apollo 11 on 20 July, 1969. Of the 24 men who ventured to the Moon, 12 walked on its surface; 22 had orbited it; three made a circumlunar flight; two made two moonflights and two orbited the Moon twice.

As the first manned Shuttle orbital flight draws nearer a total of 43 out of the 73 astronauts have left the programme (eight of these were dead) leaving 27 on the active list, with 3 on temporary leave of absense or other assignments but available for Shuttle missions. Only 14 of these have spaceflight experience with the remainder still awaiting their first mission after a period of at least 9½ years since their selection. The last Americans to fly in space took part in the ASTP mission of 1975, and closed the chapter of one-flight American space craft of the Mercury-Gemini-Apollo era. The next astronauts will ride the reusable Space Shuttle and open a new era of manned spaceflight.

The accompanying tables summarise the achievements of

Table.1. NASA Astronaut Groups – Present status.

Group	Selection Date	Category	No. Selected	No. Flown	Still Active
1	Apr. 9, 1959	Mercury Pilots	7	7	1
2	Sept. 17, 1962	Test Pilots	9	8	1
3	Oct. 18, 1963	Pilot Astro's	14	10	2
4	Jun. 28, 1965	Scientist Astro's	6	4	2
5	Apr. 4, 1966	Pilot Astro's	19	15	11
6	Aug. 4, 1967	Scientist Astro's	11	0	6
7	Aug. 14, 1969	MOL Pilots	7	0	7
8	Jan. 16, 1978	Shuttle Astro's	35	0	35
		Totals:	108	43	65

NOTE: Two astronauts (Schweickart; Swigert) classed Inactive but available for space Shuttle flights. Astronaut Pogue on Temporary **Leave of Absence.**

Table 2. U.S. Manned Spaceflights by Programme.

Programme	No. of flights	No. of Persons	Person Hours
Skylab	3	9	12,351:45
Apollo	11	33	7,506:03
Gemini	10	20	1,939:42
Apollo-Soyuz	1	3	652:24
Mercury	6	6	53:55
Totals:	31	71	22,503:49

4 People	4 times	16
3 People	3 times	9
20 People	twice	20
26 People	once	26
43 People		

Where are they now?/contd.

Table 3. Space Flight Experience.
Given in order of most accumulate time spent in space by the 43 American astronauts who have flown to date, plus their current status.

Pos.	Name	No. Flights	Total Hours : Min.	Present Status
1.	Carr	1	2017 : 15	Resigned
	Gibson	1	2017 : 15	Active
	Pogue	1	2017 : 15	Inactive
2.	* Bean (4th)	2	1671 : 45	Active
3.	Garriott	1	1427 : 09	Active
	Lousma	1	1427 : 09	Active
4.	* Conrad (3rd)	4	1179 : 38	Resigned
5.	Lovell	4	715 : 05	Resigned
6.	Kerwin	1	672 : 49	Active
	Weitz	1	672 : 49	Active
7.	* Cernan (11th)	3	566 : 15	Resigned
8.	* Scott (7th)	3	546 : 54	Resigned
9.	* Young (9th)	4	533 : 33	Active
10.	Stafford	4	507 : 43	Resigned
11.	Borman	2	477 : 36	Resigned
12.	McDivitt	2	388 : 57	Resigned
13.	Gordon	2	315 : 53	Resigned
14.	Evans	1	301 : 51	Resigned
	* Schmitt (12th)	1	301 : 51	Resigned
15.	Schirra	3	295 : 13	Resigned
16.	* Irwin (8th)	1	295 : 11	Resigned
	Worden	1	295 : 11	Resigned
17.	* Aldrin (2nd)	2	289 : 53	Resigned
18.	Collins	2	266 : 05	Resigned
19.	Mattingly	1	265 : 51	Active
	* Duke (10th)	1	265 : 51	Resigned
20.	Eisele	1	260 : 09	Resigned
	Cunningham	1	260 : 09	Resigned
21.	Schweickart	1	241 : 01	Inactive
22.	Cooper	2	225 : 15	Resigned
23.	Slayton	1	217 : 28	Active
	Brand	1	217 : 28	Active
24.	* Shepard (5th)	2	216 : 17	Resigned
25.	* Mitchell (6th)	1	216 : 02	Resigned
	Roosa	1	216 : 02	Resigned
26.	* Armstrong (1st)	2	206 : 00	Resigned
27.	Anders	1	147 : 00	Resigned
28.	Haise	1	142 : 54	Active
	Swigert	1	142 : 54	Inactive
29.	White	1	97 : 56	Deceased
30.	Grissom	2	5 : 08	Deceased
31.	Carpenter	1	4 : 56	Resigned
32.	Glenn	1	4 : 55	Resigned

* Walked on lunar surface (in order of walk)

Table 4. Extravehicular Experience.
To date a total of 26 astronauts have performed at least one EVA period each in the period June 1965 – February 1974. These varied from spacewalks in Earth orbit to EVA's on the Moon. Total American EVA experience in man hours is currently 353 : 55.

Key	Type
1	Standup EVA - Earth orbit
2	Space walk - Earth orbit
3	Standup EVA - Deep space
4	Space walk - Deep space
5	Standup EVA - Lunar
6	Lunar EVA

Pos.	Name	Flight(s)	Type	Individual Totals	Overall Total
1	Cernan	Gemini 9	2	2 : 07	
		Apollo 17	6	22 : 04	24 : 11
2	Schmitt	Apollo 17	6	22 : 04	
		Apollo 17	3	1 : 06	23 : 10
3	Duke	Apollo 16	6	20 : 14	
		Apollo 16	3	1 : 24	21 : 38
4	Scott	Apollo 9	1	1 : 01	
		Apollo 15	5	0 : 33	
		Apollo 15	6	18 : 35	20 : 09
5	Young	Apollo 16	6	20 : 14	20 : 14
6	Irwin	Apollo 15	6	18 : 35	
		Apollo 15	3	: 38	19 : 13
7	Carr	Skylab 4	2	15 : 51	15 : 51
8	Gibson	Skylab 4	2	15 : 22	15 : 22
9	Garriott	Skylab 3	2	13 : 42	13 : 42
10	Pogue	Skylab 4	2	13 : 37	13 : 37
11	Conrad	Apollo 12	6	7 : 46	
		Skylab 2	2	4 : 59	12 : 45
12	Lousma	Skylab 3	2	11 : 01	11 : 01
13	Bean	Apollo 12	6	7 : 46	
		Skylab 2	2	2 : 41	10 : 27
14	Shepard	Apollo 14	6	9 : 23	9 : 23
	Mitchell	Apollo 14	6	9 : 23	9 : 23
15	Aldrin	Gemini 12	2	5 : 30	
		Apollo 11	6	2 : 48	8 : 18
16	Kerwin	Skylab 2	2	3 : 23	3 : 23
17	Armstrong	Apollo 11	6	2 : 48	2 : 48
18	Gordon	Gemini 11	2	2 : 41	2 : 41
19	Weitz	Skylab 2	1	1 : 15	
		Skylab 2	2	1 : 06	2 : 11
20	Collins	Gemini 10	2	1 : 27	1 : 27
21	Mattingly	Apollo 16	4	1 : 24	1 : 24
22	Schweickart	Apollo 9	2	1 : 07	1 : 07
23	Evans	Apollo 17	4	1 : 06	1 : 06
24	Worden	Apollo 15	4	: 38	: 38
25	White	Gemini 4	2	: 36	: 36

NOTE: EVA time was measured differently for different space programmes. During Gemini, EVA was computed from hatch opening to hatch closing. During Apollo and Skylab, it was taken from the time cabin pressure reached 3.0 psi during depressurization and repressurization.

EVA Sub-totals

Type	Duration (Hrs : Min)
1	2 : 16
2	183 : 10
3	3 : 08
4	3 : 08
5	: 33
6	161 : 40
Total	353 : 55

Table 4A. Lunar Surface Stay Time - Apollo

Flight	Dates	Astronauts	Site	Stay time Hrs : Mins
Apollo 11	20-21/7/1969	Armstrong Aldrin	Sea of Tranquillity	21 : 36
Apollo 12	19-20/11/1969	Conrad Bean	Ocean of Storms	31 : 31
Apollo 14	5-6/2/1971	Shepard Mitchell	Fra Mauro	33 : 30
Apollo 15	30/7-2/8/1971	Scott Irwin	Hadley-Apennine	66 : 54
Apollo 16	20-23/4/1972	Young Duke	Descartes	71 : 14
Apollo 17	11-14/12/1972	Cernan Schmitt	Taurus-Littrow	74 : 59

Table 5. Deceased Astronauts (NASA)

Name	Age	NASA Group	Date	Cause of Death
Bassett	34	3	Feb.28, 1966	Jet crash
Chaffee	31	3	Jan.27, 1967	Apollo 204 fire
Freeman	34	3	Oct.31, 1964	Jet Crash
Givens	37	5	Jun.6, 1966	Automobile accident
Grissom	40	1	Jan.27, 1967	Apollo 204 fire
See	38	2	Feb.28, 1966	Jet crash
White	36	2	Jan.27, 1967	Apollo 204 fire
Williams	35	3	Oct.5, 1967	Jet crash

Table 6. Astronaut Flight Crew Assignments, MERCURY – SPACE SHUTTLE OFT (Final)

Mercury

Flight	Flight Pilot	Backup Pilot
Mercury 3	A.B. Shepard, Jr.	J.H. Glenn, Jr.
Mercury 4	V.I. Grissom	J.H. Glenn, Jr.
Mercury 6	J.H. Glenn, Jr.	M.S. Carpenter
Mercury 7	M.S. Carpenter	W.M. Schirra, Jr.
Mercury 8	W.M. Schirra, Jr.	L.G. Cooper
Mercury 9	L.G. Cooper	A.B. Shepard, Jr.

Gemini

Flight	Position	Flight Crew	Backup Crew
Gemini 3	Commander Pilot	V.I. Grissom J.W. Young	W.M. Schirra T.P. Stafford
Gemini 4	Commander Pilot	J.A. McDivitt E.H. White II	F. Borman J.A. Lovell
Gemini 5	Commander Pilot	L.G. Cooper C. Conrad, Jr.	N.A. Armstrong E.J. See, Jr.
Gemini 6	Commander Pilot	W.M. Schirra, Jr. T.P. Stafford	V.I. Grissom J.W. Young
Gemini 7	Commander Pilot	F. Borman J.A. Lovell	E.H. White, II M. Collins
Gemini 8	Commander Pilot	N.A. Armstrong D.R. Scott	C. Conrad, Jr. R.F. Gordon, Jr.
Gemini 9	Commander Pilot	T.P. Stafford E.A. Cernan	J.A. Lovell, Jr. E.E. Aldrin, Jr.
Gemini 10	Commander Pilot	J.W. Young M. Collins	A.L. Bean C.C. Williams
Gemini 11	Commander Pilot	C. Conrad, Jr. R.F. Grodon, Jr.	N.A. Armstrong W.A. Anders
Gemini 12	Commander Pilot	J.A. Lovell, Jr. E.E. Aldrin, Jr.	L.G. Cooper E.A. Cernan

Apollo

Flight	Position	Flight Crew	Backup Crew	Support Crew
Apollo 1	CDR. CMP. LMP.	Grissom White Chaffee	Schirra Eisele Cunningham	Swigert Evans Pogue
Apollo 7	CDR. CMP. LMP.	Schirra Eisele Cunningham	Stafford Young Cernan	Swigert Evans Pogue
Apollo 8	CDR. CMP. LMP.	Borman Lovell Anders	Armstrong Aldrin Haise	Swigert Mattingly Brand Carr
Apollo 9	CDR. CMP. LMP.	McDivitt Scott Schweickart	Conrad Gordon Bean	Mitchell Wordon Lousma Roosa
Apollo 10	CDR. CMP. LMP.	Stafford Young Cernan	Cooper Eisele Mitchell	Lousma Duke Engle Irwin
Apollo 11	CDR. CMP. LMP.	Armstrong Collins Aldrin	Lovell Anders Haise	Evans Mattingly Pogue Swigert
Apollo 12	CDR. CMP. LMP.	Conrad Gordon Bean	Scott Wordon Irwin	Carr Mattingly Weitz Garriott Gibson
Apollo 13	CDR. CMP. LMP.	Lovell Swigert Haise	Young Mattingly Duke	Brand Lousma Pogue

[Continued overleaf

Where are they now?/contd.

Apollo 14	CDR.	Shepard	Cernan	Pogue
	CMP.	Roosa	Evans	McCandless
	LMP.	Mitchell	Engle	Fullerton
Apollo 15	CDR.	Scott	Gordon	Allen (Mission Sc.)
	CMP.	Wordon	Brand	Heinze
	LMP.	Irwin	Schmitt	Parker
Apollo 16	CDR.	Young	Haise	England (Mission Sc.)
	CMP.	Mattingly	Roosa	Hartsfield
	LMP.	Duke	Mitchell	Peterson
Apollo 17	CDR.	Cernan	Young	Parker (Mission Sc.)
	CMP.	Evans	Roosa	Fullerton
	LMP.	Schmitt	Duke	Overmyer

Skylab

Flight	Position	Flight Crew	Backup Crew	Support Crew
Skylab 2	CDR.	Conrad	Schweickart	Crippen (Leader)
	Pilot	Weitz	McCandless	Hartsfield
	Sc. Pilot	Kerwin	Musgrave	Truly
				Thornton
Skylab 3	CDR	Bean	Brand	(same Support
	Pilot	Lousma	Lind	Crew as for
	Sc. Pilot	Garriott	Lenoir	Skylab 2)
Skylab 4	CDR.	Carr	(Same Backup and Support	
	Pilot	Pogue	Crews as Skylab 3)	
	Sc. Pilot	Gibson		

A.S.T.P.

Flight	Position	Flight Crew	Backup Crew	Support Crew
Apollo 18	CDR.	Stafford	Bean	Crippen (Leader)
	CMP.	Brand	Evans	Bobko
	DMP.	Slayton	Lousma	Overmyer
				Truly

the seven NASA astronaut groups selected between April 1959 and August 1969. Below is a brief description of the 35 astronauts recently selected by NASA to fill assignments in the Space Shuttle programme in the 1980's and 1990's.

Group 8. Shuttle Astronauts. 35 selected 16 January, 1978.

Following a year-long recruiting period which ended on 30 June, 1977, NASA had received a total of 8,079 applications for candidates for the eighth group of American astronauts. When, in early 1976, it was revealed that NASA would soon be issuing a call for astronauts for the Shuttle programme, it was expected that for the first time in any NASA astronaut group, candidates woule include women and minority applicants.

In August 1977 208 finalists began interviews and medical examinations at Johnson Space Center, Houston Texas, it was stated that following a two year training and evaluation programme at JSC, successful candidates would, in 1980, become full NASA Astronauts and enter the Shuttle training programme leading eventually to selection to a Shuttle flight crew.

The new, eighth group of astronauts, named on 16 January, 1978, totalled 35, of which 14 were civilian and 21 from the military, of the group six were women and four minorities. The breakdown of how the 35 were finally selected is given in Table 7.

The applicants were divided into two categories: Pilots and Mission Specialists. Pilots, it was stated, would operate the Space Shuttle Orbiter, manoeuvring it in Earth orbit and flying it to Earth for a runway landing. Mission specialist astronauts will, in co-ordination with both the Commander and Pilot, have overall responsibility for Shuttle activities affecting experiment operations, which may involve them undertaking periods of Extra Vehicular Activity (EVA); perform special payload handling or even experiment operation. Mission specialist astronauts will also be responsible for crew activity planning and consumable usage.

In Group 8 there are 15 astronauts in training as Pilots and 20 astronauts training as Mission Specialists.

The astronauts

BLUFORD, Jr. Guion S. Major USAF (PhD). Born 22 November, 1942, Philadelphia Pa., Phildelphia. Married to the former Linda M. Tull of Philadelphia, Pa., two children. Current residence Dayton Ohio. Education; Overbrook Senior High School, Philadelphia; BS, Aerospace Engineering, Pennsylvania State University, 1964; MS, Aerospace Engineering, Air Force Institute of Technology, 1974; PhD, Aerospace Engineering, Air Force Institute of Technology, 1977. Present position; Chief, Aerodynamics and Airframe Branch, Aerodynamics Division, Air Force Dynamics Laboratory, Wright-Patterson AFB, Ohio. Category, Mission Specialist. (Minorities astronaut).

BRANDENSTEIN, Daniel C. Lt. Commander, USN. Born 17 January, 1943, Watertown, Wisconsin. Married to the former Jane A. Wade of Amery, WI. They have one child. Current residence Oak Harbor, WA. Education; Watertown High School, Watertown WI. BS, Mathematics/Physics, University of Wisconsin, 1965. Present position; Naval Aviator and Maintenance Officer, Attack Squadron One Four Five, NAS Whidbey Island, Oak Harborr, WA. Category; Pilot.

BUCHLI, James F. Captain USMC. Born 20 June, 1945, New Rockford, South Dakota. Married to the former Sandra J. Oliver, two children. Current residence Lexington Park, MD, Education, Fargo Central High School, Fargo ND; BS, USN Academy, 1967; MS, Aeronautical Systems, University of West Florida, 1975. Present position; Student U.S. Naval Flight Test Engineering School Patuxent River, MD. Category, Mission Specialist.

COATS, Michael L. Lt. Commander, USN. Born 16 January, 1946, Sacramento California. Married to the former Diane E. Carson of Oklahoma City, one child. Current residence, Great Mills MD. Education; Ramona High School, Riverside, CA; BS, USN Academy, 1968; MS, Admin. of Science and Technology, George Washington University, 1977. Present position; Student, U.S. Navy Postgraduate School, Monterey, CA. Category, Pilot.

COVEY, Richard O, Major USAF. Born 1 August, 1946, Fayetteville, Arizona. Married to the former Kathleen Allbough of Indiano la, IA, two children. Current residence Fort Walton Beach, FL. Education; Choctawhatchee High School, Shalimar, FL; BS, USAF Academy, 1968; MS, Aeronautical/Astronautical Engineering, Purdue University, 1969. Present position; Commander, F-15 Joint Test Force, Air Force Test Center Detachment 2, Eglin AFB, Florida. Category, Pilot.

CREIGHTON, John O. Lt. Commander, USN. Born 28 April, 1923, Orange, Texas. Unmarried. Current residence, Lexington Park, MD. Education; Ballard High School, Seattle WA; BS,

Where are they now?/contd.

ASTRONAUT CANDIDATES SELECTED JANUARY, 1978

MEN AND WOMEN OF THE SHUTTLE ERA. The thirty-five new astronaut candidates in alphabetical order. Biographies are given on pages 162, 164-166.

National Aeronautics and Space Administration

USN Academy, 1966. Present position; Test Pilot, Naval Air Test Center, Patuxent River, MD. Category, Pilot.

FABIAN, John M. Major USAF (PhD). Born 28 January, 1939, Goosecreek, Texas. Married to the former Donna K. Bulbotz of Lewiston, ID, two children. Current residence, Colorado Springs, Colorado. Education; Pullman High School, Pullman, WA; BS, Mechanical Edgineering, Washington State University, 1962; MS, Aerospace Engineering, Air Force Institute of Technology, 1964; PhD, Aeronautics/Astronautics, University of Washington, 1974. Present position, Assistant Professor of Aeronautics, USAF Academy, CO. Category, Mission Specialist.

FISHER, Anna L. Civilian M.D. Born 24 August, 1949, Albany, New York. Married to Dr. William F. Fisher of Dallas, Texas, no children. Current residence, Rancho Palos Verdes, CA. Education; San Pedro High School, San Pedro, CA; BS, Chemistry, University of California, Los Angeles, 1971; MD, University of California, Los Angeles, School of Medicine, 1976. Present position, Physician, Los Angeles, California. Category, Mission Specialist (Female).

GARDNER, Dale A. Lieutenant, USN. Born 8 November, 1948, Fairmont, MN. Married to the former Sue G. Ticusan of Indianapolis, IN, one child. Current residence, Camarillo CA. Education; Savanna Community High School, Savanna, IL; BS, Engineering Physics, University of Illinois, 1970. Present position, Naval Flight Officer, Air Test and Evaluation Squadron Four, NAS Point Mugu, California. Category, Mission Specialist.

GIBSON, Robert L. Lieutenant USN. Born 30 October, 1946, Cooperstown, New York. Married to the former Cathy M. Von Epps of Santa Barbara, CA, one child. Current residence, Leonardtown, MD. Education; Huntington High School, Huntington, NY; BS, Aeronautical Engeering, California Polytechnic State University, 1969. Present position, Test Pilot Naval Air Test Center, Patuxent River, Maryland. Category, Pilot.

GREGORY, Frederick D. Major USAF. Born 7 January, 1941, Washington, D.C. Married to the former Barbara A. Archer of Newport News, VA, two children. Current residence, Hampton, VA. Education; Anacostia High School, Washington D.C. BS, USAF Academy, 1964, MS, Information Systems, George Washington University, 1977. Present position, Armed Forces Staff College Norfolk, Virginia. Category, Pilot (Minority astronaut).

GRIGGS, Stanley D. Born 7 September, 1939, Portland, Oregan. Married to the former Karen F. Kreeb of Port Jefferson, New York, two children. Current residence, Seabrook, Texas. Education; Lincon High School, Portland OR; BS, USN Academy, 1962, MSA Management Engineering, George Washington University, 1970. Present position, Chief, Shuttle Training Aircraft Operations Office, NASA/ Johnson Space Center, Houston, Texas. Category, Pilot.

HART, Terry J. Civilian. Born 27 October, 1946, Pittsburgh, Pennsylvania. Married to the former Wendy M. Eberhardt of Warren, PA, one child. Current residence, Long Valley, New Jersey. Education; Mt. Lebanon High School, Pittsburgh, PA; BS, Mechanical Engineering, Lehigh University, 1968; MS, Mechanical Engineering, Massachusetts Institute of Technology, 1969. Present position, Technical Staff Member, Bell Telephone Laboratories, Whippany, NJ. Category, Mission Specialist.

HAUCK, Frederick H. Commander, USN. Born 11 April, 1941. Long Beach, California. Married to the former Mary E. Bowman of Washington D.C. They have two children. Current residence, Oak Harborr, WA. Education; St. Albans High School, Mt. St. Alban, Washington, D.C. BS, General Physics, Tufts University, 1962; MS, Nuclear Engineering, Massachusetts Institute of Technology, 1966. Present position, Executive Officer, Attack Squadron One Four Five, NAS Whidbey Island, Oak Harborr, WA. Category, Pilot.

HAWLEY, Steven A. Civilian PhD. Born 12 December, 1951, Ottawa, Kansas. Unmarried. Current residence Santa Cruz, CA. Education; Salina Central High School, Salina, KS; BS, Astronomy and Physics, University of Kansas, 1973, PhD, Astronomy, University of California, Santa Cruz, 1977. Category, Mission Specialist.

HOFFMAN, Jeffrey A. Civilian PhD. Born 2 November, 1944, New York, NY. Married to the former Barbara C. Attridge of London, England, one child. Current residence, Weston MA. Education; Scarsdale High School, Scarsdale, NY; BA, Astronomy, Amherst College, 1966; PhD, Astrophysics, Harvard University, 1971. Present position, Astrophysics Research Staff, Massachusetts Institute of Technology Center for Space Research, Cambridge, MA. Category, Mission Specialist.

LUCID, Shannon W. Civilian, PhD. Born 14 January, 1943, Shanghai. China. Married to Michael F. Lucid of Indianapolis, IN, three children. Current residence, Oklahoma City, OK. Education; Bethany High School, Bethany, OK; BS, Chemistry, University of Oklahoma, 1963; MS, Biochemistry, University of Oklahoma, 1973. Present position, Postdoctoral Fellow, Oklahoma Medical Research Foundation, Oklahoma City OK. Category, Mission Specialist (Female).

McBRIDE, Jon A. Lt. Commander, USN. Born 14 August, 1943, Charleston, WV. Married to the former Brenda L. Stewart of Bayou La Batre, LA, three children. Current residence, Point Mugu, CA. Education; Woodrow Wilson High School, Berkley, WV; BS, Aeronautical Engineering, USN Postgraduate School, 1971. Present position, Test Pilot, Air Test and Evaluation Squadron Four, Point Mugu, CA. Category, Pilot.

McNAIR, Ronald E. Civilian PhD. Born 21 October, 1950, Lake City, SC. Married to the former Cheryl B. Moore of Brooklyn, NY, no children. Current residence Marina Del Rey, CA. Education; Carver High School, Lake City, SA; BS, Physics, North Carolina A & T University, 1971; PhD, Physics, Massachusets Institute of Technology, 1977. Present position, Member of the Technical Staff, Optical Physics Department, Hughes Research Laboratories, Malibu, CA. Category, Mission Specialist (Minority astronaut).

MULLANE, Richard M. Captain USAF. Born 10 September, 1945, Wichita Falls, Texas. Married to the former Donna M. Sei of Albuquerque, three children. Current residence, Fort Walton Beach, Florida, Education; St. Pius X High School Albuquerque; BS, U.S. Military Academy, 1967; MS, Aeronautical Engineering, Air Force Institute of Technology, 1975. Present position, Flight Test Weapon Systems Operator, 3246th Test Wing, Eglin AFB, Florida. Category, Mission Specialist.

NAGEL, Steven R. Captain USAF. Born 27 October, 1946, Canton, IL. Married to the former Linda D. Penney of Los Angeles, CA, no children. Current residence, Edwards, CA. Education; Canton High School, Canton, IL; BS, Aeronautical/Astronautical Engineering, University of Illinois, 1969, Present position, Test pilot, Air Force Flight Test Center, Edwards AFB, California. Category, Pilot.

NELSON, George D. Civilian, PhD. Born 13 July, 1950,

Charles City, IA. Married to the former Susan L. Howard of Alhambra, CA, two children. Current residence, Seattle, Washington. Education; Willmar Senior High School, Willmar, MN; BS, Physics, Harvey Mudd University, 1972; MS Astronomy, University of Washington, 1974; PhD, Astronomy, University of Washington, 1977. Present position, Research Associate, Astronomy Department, University of Washington, Seattle Washington. Category, Mission Specialist.

ONIZUKA, Ellison S. Captain USAF. Born 24 June, 1946, Kealakekua Hawaii. Married to the former Lorna L. Yoshida of Pahala, HI, three children. Current residence Edwards AFB, CA. Education; Konawaena High School, Kealakekua, HI; BS, Aerospace Engineering, University of Colrado, 1969; MS, Aerospace Engineering, University of Colorado, 1969. Present position, Chief, Engineering Support Section, Training Resources Branch, USAF Test Pilot School, Edwards AFB, CA. Category, Mission Specialist (Minority Astronaut).

RESNIK, Judith A. Civilian, PhD. Born 5 April, 1949, Akron, Ohio. Unmarried. Current residence, Rendondo Beach, CA. Education; Firestone High School, Akron, OH; BS, Electrical Engineering, Carnegie-Mellon University, 1970; PhD, Electrical Engineering, University of Maryland, 1977. Present position, Engineering Staff, Product Development, Xerox Corporation, El Segundo, CA. Category, Mission Specialist (Female).

RIDE, Sally K. Civilian. Born 26 May, 1951, Los Angeles, California. Unmarried. Current residence, Stanford CA. Education; Westlake High School, Los Angeles, CA; BS, Physics, Stanford University, 1973; BA, English, Stanford University, 1973; MS, Physics, Stanford University, 1975. Present position, Research Assistant, Physics Department, Stanford University, Stanford, CA. Category, Mission Specialist (Female).

SCOBEE, Francis R. Major USAF, Born 19 May, 1939, Cle Elum, WA. Married to the former Virginia J. Kent of Birmingham, AL. two children. Current residence, Edwards AFB, CA. Education; Auburn High School, Auburn WA; BS, Aerospace Engineering, University of Arizona, 1965. Present position, Test Pilot, Air Force Flight Test Center, Edwards AFB, CA. Category, Pilot.

SEDDON, Margaret R. Civilian MD. Born 8 November, 1947, Murfreesboro, TN. Unmarried. Current residence, Memphis TN. Education; Central High School, Murfreesboro, TN; BA, Physiology, University of California, Berkeley, 1970; MD, University of Tennessee College of Medicine, 1973. Present position, Resident Physician, Department of Surgery, City of Memphis Hospital, Memphis, TN. Category, Mission Specialist (Female).

SHAW, Jr. Brewster H. Captain USAF. Born 16 May, 1945, Cass City, MI. Married to the former Kathleen A. Mueller of Madison, WI, three children. Current residence, Edwards CA. Education; Cass City High School, Cass City, MI; BS, Engineering Mechanics, University of Wisconsin, 1968; MS, Engineering Mechanics, University of Wisconsin, 1969. Present position, Instructor, U.S. Air Force Test Pilot School, Edwards AFB, CA. Category, Pilot.

SHRIVER, Loren J. Captain USAF. Born 23 September, 1944, Jefferson IA. Married to the former Susan D. Hane of Jefferson IA, four children. Current residence Edwards AFB, CA. Education; Paton Consolidated High School, Paton, IA; BS, USAF Academy, 1967; MS, Astronautics, Purdue University, 1968. Present position, Test Pilot, Air Force Flight Test Center, Edwards AFB, CA. Category, Pilot.

Space Shuttle

Flight	Position	Flight Crew	Backup Crew
ALT Crew 1	Commander	Haise	Engle
	Pilot	Fullerton	Truly
ALT Crew 2	Commander	Engle	Haise
	Pilot	Truly	Fullerton
OFT Crew 1	Commander	Young	Engle
	Pilot	Crippen	Truly
OFT Crew 2	Commander	Engle	
	Pilot	Truly	
OFT Crew 3	Commander	Haise	
	Pilot	Lousma	
OFT Crew 4	Commander	Brand	
	Pilot	Fullerton	

NOTE: No Support Crews were assigned to either Mercury or Gemini missions.assignment gives final positions only at time of flight:
Key: CDR - Commander, CMP - Command Module Pilot, LMP - Lunar Module Pilot, DMP (ASTP) - Docking Module Pilot, ALT - Approach and Landing Tests, OFT - Orbital Flight Tests.

STEWART, Robert L. Major U.S. Army. Born 13 August, 1942, Washington, DC. Married to the former Mary J. Murphy of La Grange, GA, two children. Current residence, Edwards, CA. Education; Hattiesburg High School, Hattiesburg, MS; BS, Mathematics, University of Southern Mississippi, 1964; MS, Aerospace Engineering, University of Texas, Arlington, 1971. Present position, Test Pilot, U.S. Army Aviation Engineering Flight Activity, Edwards AFB, CA. Category, Mission Specialist.

SULLIVAN, Kathryn D. Civilian PhD. Born 3 October, 1951, Paterson, NJ. Unmarried. Current residence, Halifax, Nova Scotia, Canada. Education; Taft High School, Woodland Hills, CA; BS, Earth Sciences, University of California, Santa Cruz, 1973; PhD, Geology, Dalhousie University, Halifax, Nova Scotia, 1978. (Miss Sullivan received her PhD in Geology from the University of Dalhousie in April 1978. She does not have a master's degree). Present position, Post-graduate Student National Research Council, Dalhousie University, Halifax, Nova Scotia, Canada. Category, Mission Specialist (Female).

THAGARD, Norman E. Civilian MD. Born 3 July, 1943. Marinna, FL. Married to the former Rex K. Johnson of Atlantia, GA, two children. Current residence, James Island, SC. Education; Paxon High School, Jacksonville, FL; BS, Engineering Science, Florida State University, 1965; MS, Engineering Science, Florida State University, 1966; MD, University of Texas Southwestern Medical School, 1977. Present position, Intern, Department of Internal Medicine, Medical University of South Carolina, Charleston, SC. Category, Mission Specialist.

VAN HOFTEN, James D. Civilian PhD. Born 11 June, 1944, Fresno, CA. Married to the former Vallerie Davis of Pasadena, CA, two children. Current residence, Houston, Texas. Education; Mills High School, Millbrae, CA; BS, Civil Engineering, University of California, Berkeley, 1966; MS, Hydraulic Engineering, Colorado State University, 1968; PhD, Fluid Mechanics, Colorado State University, 1976. Present position, Assistant Professor of Civil Engineering, University of Houston, Houston, Texas. Cateogry, Mission Specialist.

Where are they now?/contd.

Table 7. GROUP 8 Selection Breakdown

Pilots

Qualified Applicants	Interviewed	Medically Qualified	Qualified/ Interested	Selected
147 Military (4 Minority)	76 Military (3 Minority)	71 Military (2 Minority)	70 Military (2 Minority)	14 Military (1 Minority)
512 Civilian (6 Minority) (3 Female)	4 Civilian	4 Civilian	4 Civilian	1 Civilian

Mission Specialists

Qualified Applicants	Interviewed	Medically Qualified	Qualified/ Interested	Selected
161 Military (6 Minority) (3 Female)	45 Military (4 Minority) (2 Female)	34 Military (3 Minority) (2 Female)	34 Military (3 Minority) (2 Female)	7 Military (2 Minority)
5519 Civilians (332 Minority) (1248 Female)	83 Civilians (8 Minority) (19 Female)	43 Civilians (4 Minority) (12 Female)	41 Civilians (4 Minority) (12 Female)	13 Civilians (1 Minority) (6 Female)

DOD Astronaut Candidates

Service	Pilot	Mission Specialist	Total
Air Force	6	4	10
Navy	8	1	9
Marine	0	1	1
Army	0	1	1
		Total	21

WALKER, David M. Lt. Commander, USN. Born 20 May, 1944, Columbus GA. Married to the former Patricia A. Shea, two children. Current residence, Virginia Beach, VA. Education; Eustis High School, Eustis, FL; BS, USN Academy, 1966. Present position, Naval Aviator VF - 142 (USS America). Category, Pilot.

WILLIAMS, Donald E. Lt. Commander, USN. Born 13 February, 1942 Lafayette, IN. Married to the former Lind J. Grubaugh of Stugis, MI, two children. Current residence, Lemoore, CA. Education; Otterbein High School, Otterbein, IN; BS, Mechanical Engineering, Purdue University, 1964. Present position, Naval Aviator, Readiness Training Squadron, NAS Lemoore, CA. Category, Pilot.

Summary and Conclusion

A total of 108 astronauts were selected to fly America's manned space missions in the 1960's - 1990's. It is 20 years since the first of them were chosen in April 1959 and in that time the word 'ASTRONAUT' has passed from the pages of science fiction into the background of modern technology.

Within those two epic decades, NASA astronauts have spent months in Earth orbit, walked in space and walked and driven across the Moon, without losing one of their number in space, though eight have died on Earth (three in a spacecraft accident at Cape Canaveral).

Throughout the courage and dedication of these men was an inspiration. Six American flags were emplaced on the Moon, but the message of Apollo was truly international: "We came in peace for ALL mankind."

Only one of the original 'Seven' remains on the flight rosta for the Shuttle programme – 'Deke' Slayton. By far the longest-serving of the astronaut corps he is the veteran's veteran.

How many new astronauts will remain active 20 years from now as we move into the 21st century – and what their attainments may be – we can only guess. Could their number include the man or woman destined to be first to leave footprints on the sands of Mars?

Whereever they may travel we wish them happy landings.

AMENDMENTS

Armstrong, N. A. Original Backup Cdr. Apollo 9; original Cdr. Apollo 12.
Conrad, Jr. C. Original Backup Cdr. Apollo 8; original Cdr. Apollo 11, due to flight reassignments lost chance of becoming first man on the Moon.
Cooper, L. G. First man to orbit the Earth twice.
Kerwin, J. P. Space Shuttle work (Payload Support, crew stations, controls and displays for the life sciences).
Lind, D. L. Co-Investigator Skylab Experiment S230(ATM) Magnetospheric Particle Composition Experiment.
Pogue, W. R. Support crew Apollo 13.

SPACE REPORT

A regular monthly review of Space Events and Technical Trends

TITAN T34D

The next generation of Titan launch vehicles, the T34D, is progressing at a steady pace despite the promise of the re-usable NASA Space Shuttle. The Chemical Systems Division of United Technologies recently received a $62,898,000 contract for production of five pairs of the 250 ton, 1.2 million lbf (0.54 m kgf) thrust solid propellant rocket boosters

The contract from the Air Force Space and Missile Systems Organisation (SAMSO) calls for delivery of the first of the 120 in (305 cm) diameter, 90 ft (27.4 m) tall boosters in September 1980.

CSD's five-segment solid propellant rockets have been used in pairs for the last decade as the booster stage of the Air Force's Titan III-C, D and E space launch vehicles. Under a separate contract from SAMSO, CSD is completing its last production of five-segment motors and starting development and production of five and one half segment motors for use on the T34D, the advanced version of the Air Force's Titan standard space vehicle. Two five and one half segment rocket boosters will launch the T34D on its maiden flight from Cape Canaveral in 1980. The extra half segment is located just below the rocket's forward closure and will provide increased thrust for heavier defense payloads of the 1980's. The five and one half segment boosters also will be compatible with the Air Force's Inertial Upper Stage (IUS), to be used as the new upper stage of the T34D. The IUS also will be employed by NASA's Space Shuttle to send payloads into higher orbit and on interplanetary missions. CSD is producing the IUS solid rocket propulsion system as well as the thrust vector control (TVC) servoactuator system.

CSD's solid rocket boosters have launched 52 Titan III vehicles in the past decade without a single flight failure. Among the more notable payloads have been the two Viking Mars landers, the first and second U.S.-West German Helios solar satellites, the two Voyager mission to Jupiter and Saturn and a series of large reconnaissance satellites (the 'Big Bird' family).

CSD developed the concept of segmenting large solid propellant rockets in the late 1950's, thereby making it possible to handle and ship propulsion systems impractical to handle in one piece. Booster segments are stacked and then secured on opposite sides of the Titan core vehicle. Their full thrust of nearly 2.5 million lbf (1.13 m kgf) is attained within a fraction of a second. In less than two minutes at an altitude of 29 miles (46.7 km) the boosters have expended all of their 470 tons of propellant. CSD staging rockets, four forward and four aft on each booster, fire for less than a second in pushing the empty boosters away from the core vehicle.

PRAISE FOR METEOSAT

The European Space Agency has been winning high praise from meteorologists all around the world for the quality of Meteosat data. Launched on 23 November 1977, the satellite reached its geostationary position at 0° longitude over the Gulf of Guinea the following December.

The first year in orbit showed how extremely well the onboard equipment is working and how the satellite is carrying out to perfection its image-taking, dissemination and data-collection missions.

During the year ground facilities set up at the European Space Operations Centre (ESOC) Darmstadt, Germany, for the reception, processing, archiving and dissemination of meteorological data from the satellite, have gradually become operational. These same facilities are now fulfilling all requirements for the first GARP (Global Atmospheric Research Programme) experiment which began on 1 December 1978.

Meteosat, which transmits every half hour excellent quality visible and infrared images of the Earth, is now retransmitting to the primary and secondary data user stations some 300 formats per day in various digital or analogue forms. It also acts as a relay for the dissemination of image data from the US satellite GOES 1 over the Atlantic which are transmitted by the Centre de Météorologie Spatiale (CMS) at Lannion at the rate of about 20 formats per day. In addition, the first transmission tests *via* Meteosat of image data from the US GOES 3 satellite, located over the Indian Ocean, began last November.

In this way, users of the four PDUS's and the forty or so SDUS's currently in service in the Meteosat coverage area can receive the data from three geostationary satellites covering approximately two-thirds of the globe.

Experiments also have been carried out during the year with data-collection platforms. They have given proof of the high quality of the links between Meteosat and the mobile platforms. About 15 DCP's are operational and early this year about 10 more were in the process of being admitted.

In addition to image acquisition and dissemination, one of the missions of the Meteosat system is to supply immediately usable meteorological products such as wind speed, cloud height, sea-surface temperature,etc.

The quality of the Meteosat images is impressive. The results already achieved are at least comparable with those obtained by the other geostationary satellites participating in the GARP. The use of the water-vapour channel, which is one of the original features of Meteosat, is considered by the meteorological community as a major advance in the refinement of interpretation techniques.

SPUTNIKS IN LONDON

Space exhibits may be included in the Soviet national exhibition to be held in London from 23 May to 10 June. Venue is the Earls Court exhibition centre. Further information is awaited.

GOONHILLY 4

The latest 'space antenna' at Goonhilly Earth station in Cornwall will open up a new era in space age communications. Called Goonhilly 4, the £3.25 million all-British antenna was designed and built by Marconi Communications Systems with the aid of £850,000 from the UK Department of Industry.

Goonhilly 4, says the Post Office, will ensure that Britain's telecommunications industry is equipped to meet the technological challenge in global communications presented by the next satellite generation.

One of its tasks will be to send test speech and television signals to the Orbital Test Satellite (OTS) launched last May by the European Space Agency.

The OTS, the first of a new generation of satellites, is spearheading a major international project – Europe's own

satellite system. In the 1980's, the system will provide high-capacity links across Europe and the Mediterranean to meet demand for telephone calls and live television pictures.

PROGNOZ 7

On 30 October (at 0323 Moscow time) the Soviet Union launched the seventh satellite in the Prognoz series, writes Neville Kidger. Its function is to study the corpuscular and electro-magnetic emissions of the Sun, streams of solar plasma, and the magnetic fields in near-Earth space with the aim of determining the influence of solar activity on interplanetary space and the Earth's magnetosphere; also the study of galactic ultra-violet, X-ray and gamma ray emissions. Gamma ray burst detection equipment was designed by French specialists. Other equipment on the station was designed by scientists from the USSR, Hungary, Czechoslovakia and Sweden.

The launch vehicle (probably an A-2-e) put the satellite into a highly elliptical orbit having an apogee of 202,965 km and a perigee of 483 km. The initial period of revolution was 98 hours 8 minutes at an inclination of 65°.

CNES, the French national space agency, said that the Prognoz carried three French experiments, the gamma ray detector being part of a five spacecraft network triangulating the sources of the recorded gamma rays. The other space vehicles involved were Prognoz 6, launched in 1977 and the French satellite Signe 3, launched in 1977 by a Soviet C-1 launch vehicle; also the probes Venera 11 and 12.

A second French experiment, *Galaktika 2*, recorded the spectra of distant ultra-violet sources. A similar recorder, *Galaktika 1*, was carried aboard the Prognoz 6 station. That recorder enabled researchers to obtain over 4,000 spectra of different regions of the sky, individual stars and star concentrations and collected a great body of data on the glow of the geocorona, a large hydrogen cloud enveloping the Earth to almost 1/3rd of the distance from the Earth to the Moon. *Galatika 2,* an improved spectrophotometer, "is able to register radiation and transmit spectra over the 202,000 km apogee of the Prognoz 7 station, away from the effects of the geocorona."

The scientists involved in the experiment at the Crimea Astrophysical Observatory of the USSR Academy of Sciences and the French Laboratory of Astronomy in Marseilles reported that the first spectrograms received were "rather encouraging." The investigators were hoping to obtain detailed information relating to the glow of the Galaxy and the density of the geocorona.

In co-operation with the Venera 11 and 12 probes Prognoz 7 participated in studying the effects of the propogation of solar wind in the interplanetary medium. Similar instruments for this study were installed on all three spacecraft, as were probes "for comprehensive research into interplanetary plasma... separate measurements of the proton and alpha-particle components of the solar wind at various distances from the Sun for the study of the process of the acceleration of interplanetary plasma."

Soviet and Swedish scientists began co-operating in joint studies into solar activities with the launch, in 1976, of the Intercosmos 16 satellite. The first attempt at launching the satellite failed and the Intercosmos 16 satellite actually put into orbit was the reserve model. Prognoz 7 carried a Soviet Swedish experiment called *PRONEK* comprising a Swedish electro-magnetic analyser and a Soviet magnetometer. Scientists from both countries were scheduled to meet in late 1978/early 1979 to assess the results of the returned data. Information transmitted from Prognoz 7 was being processed at the USSR Institute of Space Research and the Swedish Kiruna Geophysical Institute.

SECOND SPACELAB SCIENCE CREW

Four American scientists have been named to serve as Payload Specialists during the second Spacelab mission scheduled for 1981.

The scientists selected are:

Dr. Loren W. Acton of Palo Alto, California, a research scientist at the Lockheed Palo Alto Research Laboratory.

Dr. John-David F. Bartoe of Reston, Virginia, a research physicist at the U.S. Naval Research Laboratory, Washington, D.C.

Dr. Dianne K. Prinz of Alexandria, Virginia, a research physicist at the U.S. Naval Research Laboratory, Washington, D.C.

Dr. George W. Simon of Alamagordo, New Mexico, chief of the solar research branch at the Air Force Geophysics Laboratory with permanent duty location at the Sacramento Peak Observatory, Sunspot, New Mexico.

Prior to the flight, two will be selected to actually fly aboard the orbiting space laboratory and operate the scientific investigations planned for the mission. The other two will operate ground-based experiment and assist the pair in orbit.

The Payload Specialists were selected by the Spacelab Investigators Working Group (IWG), which is composed of the Spacelab 2 Principal Investigators, who will have experiments aboard the mission. Each Payload Specialist is a Co-Investigator on one of the experiments to be flown aboard Spacelab 2.

The position of Payload Specialist is a new one in the space programme. Payload Specialists are not professional astronauts and are not required to pilot or operate the Space Shuttle, which will carry the Spacelab on its missions. They will, instead, devote themselves to the operation of experiments just as a scientist would do in a ground-based laboratory except that their laboratory, Spacelab, is in orbit.

The Spacelab 2 Payload, managed by NASA's Office of Space Sciences, consists of scientific investigations primarily in the areas of astronomy, high energy astrophysics and solar physics research. Experiments also will be performed in plasma physics, botany, medicine and space technology.

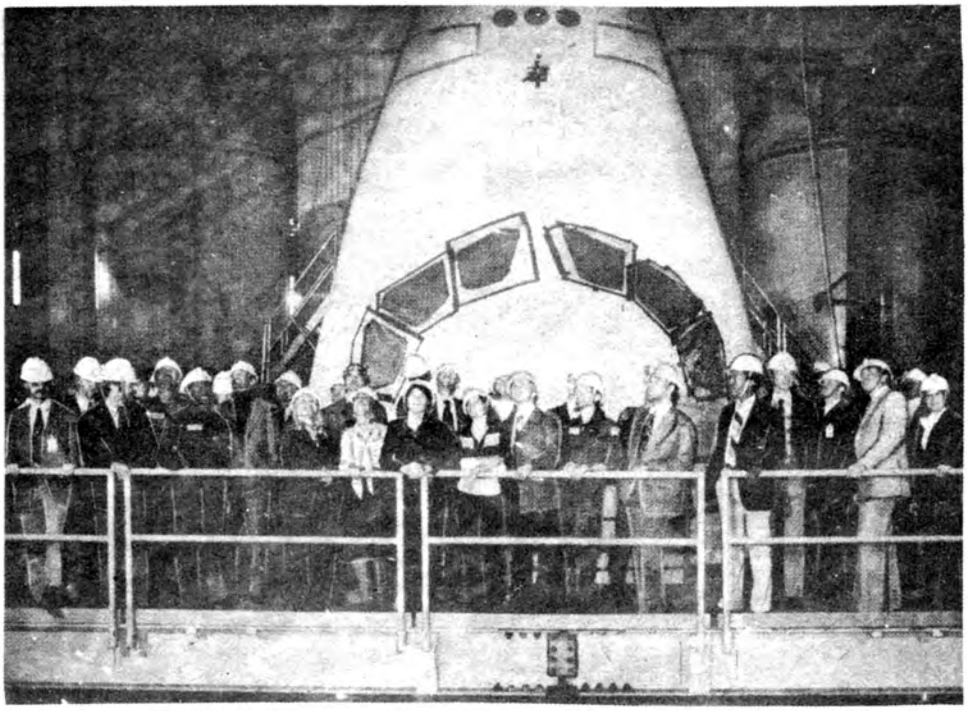
Spacelab 2 is a Spacelab "pallet only" mission with the scientific instruments exposed to space in the cargo bay of the Space Shuttle Orbiter. Because there is no habitable module included in this configuration, the Payload Specialists will operate their experiment equipment from the Shuttle Orbiter's crew cabin. The mission is scheduled to be launched from NASA's Kennedy Space Center, Florida, in 1981 and will orbit the Earth at an altitude of about 450 km (250 miles) for nine days.

SPACELAB INTEGRATION

NASA has decided to conduct all physical integration of Spacelab experiments related to the Space Shuttle at the Kennedy Space Centre.

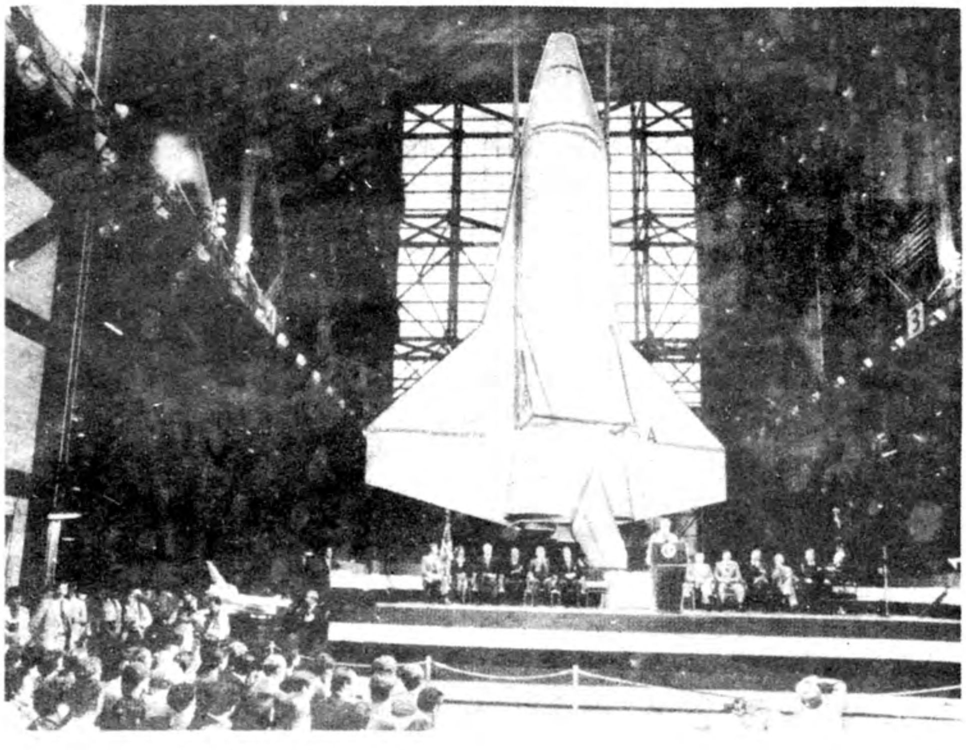
The decision follows extensive analysis and cost studies, and confirms an earlier tentative decision to perform the work at Kennedy rather than at the centres charged with managing the Spacelab missions. (The Marshall Center has

Space Report/contd.



SHUTTLE CREWS OF THE FUTURE. The 35 new astronaut candidates selected by NASA last year got their first look at a complete Space Shuttle during a recent training visit to the Marshall Space Flight Center in Huntsville, Alabama. They are standing on a steel 'bridge' several hundred feet up inside the Marshall Center's dynamic test building where the Shuttle is undergoing test. Behind them is the cockpit area and nose of the Orbiter 'Enterprise.' The large white tubular structures in the background are the Shuttle's external tank and solid rocket boosters.

National Aeronautics and Space Administration



JIMMY CARTER AT THE CAPE. President Carter addresses a large audience of NASA employees and their families in the Vehicle Assembly Building, Kennedy Space Center, Florida, on 1 October on the occasion of the 20th anniversary of the National Aeronautics and Space Administration. Behind the President is a full-scale mock-up of the Space Shuttle Orbiter (see also page 159).

management responsibility for the first three such missions).

Physical integration involves actual installation of the experiments on Spacelab's racks and pallets. When Spacelab operations become routine in the mid-1980's, the physical integration is expected to require about 100 civil service and contractor man-years of work each year at Kennedy.

Analytical work required to integrate experiments for each Spacelab mission will continue to be done at assigned mission management centres.

SHUTTLE FLIGHTS IDENTIFICATION

John F. Yardley, NASA Associate Administrator for Space Transportation Systems, has announced a redesignation for Space Shuttle flights because the previous nomenclature was deemed "not all inclusive of the mission description."

The first orbital flight will be STS-1, followed by STS-2 and continuing sequentially through the STS operations era.

COSMOS AND THE RADIO SATELLITES

On 28 October 1978 the Soviet Union launched three satellites on one carrier rocket into an orbit not previously used by the Soviets, prompting speculation that it was the first operational use of a new launch vehicle,writes Neville Kidger. Recently the Soviets have launched three satellites into a 76° inclined orbit from the Plesetsk launch site. P. S. Clark has speculated that this may herald the phasing out of the C-1 launcher (see "The Skean Programme" in *Spaceflight*, August 1978, pp. 298-304.

The Cosmos satellite carried into the new 1,724 x 1,688 km orbit at an inclination of 82.6° was number 1045 in the series. The mission of the satellite is unknown but may be related to the Cosmos navigation series. The Cosmos satellite was accompanied into orbit by two small pick-a-back satellites, designed and built by radio hams, called Radio 1 and 2.

The Soviets announced in 1977 that they were intending to launch, in 1978, four such satellites. They were initially expected to be launched with satellites of the Meteor metsat series. In 1977 it was reported that the Soviet amateur radio relay satellites would complement the US OSCAR satellite system that has, since its inception in 1961, been providing the service. The Soviets have designated their system RS. One of the space relay satellites was put into an orbit inclined at 82.54° and the other at an inclination of 82.51°, at altitudes very similar to that of Cosmos 1045.

Tass stated that "the data necessary for organizing communications for radio hams will be published in the press and reported through radio stations of the Central Radio Club and receiving and command posts of the Voluntary Society for Assistance to the Army, Air Force and Navy of the USSR (DOSAAF). Control of the operation of Radio 1 and Radio 2 and reception and processing of information relayed from them will be implemented by the ground receiving and command posts of the DOSAAF.... Students of higher educational establishments and DOSAAF radio hams who created Radio 1 and Radio 2 and the receiving and command points on the ground dedicate this space experiment to the 60th anniversary of the Lenin Komsomol."

Radio Moscow explained that the "maximum duration of a radio contact *via* the satellites is 25 minutes. The maximum distance on Earth between two radio operators using the satellites is 8,000 km. An average daily radio traffic handled by the satellites is expected to be 10 sessions for the Soviet territory and from seven to eight for the US..... Their relays operate in a band from 145.880 to 145.920 MHz (uplink frequency, 100kc bandwidth); 29.360 to 29.400 MHz (downlink frequency, 100kc bandwidth). Beacons beam the RS signal in Morse code on 29.400 MHz, outward power is up to 1.5 watts." One satellite transmits an "RS" Morse code pattern while the second transmits an "RS-RS" signal. One of the satellites is hermetically sealed while the other has its instruments exposed to the space environment.

The Soviets have made a point of noting that the Radio satellites were built by college students "going into DX-ing" (DX is the Soviet term for radio hams) whereas the OSCAR satellites were manufactured by industrial firms.

Concern was expressed by US amateurs about the altitude of the satellites (the Soviets had indicated earlier that this would be about 800 km lower than the actual orbits used) as the satellites were placed in the region of the Earth's radiation belts where it was feared that solar cell or other system degradation could occur rapidly.

The news agency *Tass* claims that there are over 2,000,000 DX-ers in the USSR with over 26,000 radio ham stations operating on short and ultra short wave in contact with other hams in the USSR and abroad. There has apparently been very little restriction on the activities of these DX-ers by the authorities. The Soviets have also claimed that a ham from the USSR holds the European record for distance communications of 2,300 km in the ultra short wave band. The Soviet DX-ers space experiences reportedly began on 4 October 1957 when the USSR Academy of Sciences asked them to tune into the signals from the world's first satellite. Over 10,000 were reported to have done so.

The first man to use the Radio satellites to communicate with another ham was Konstantin Khataturov, call-sign UW3 HV, who has been DX-ing for 21 years. He said that the returned signal was good and stable reception was achieved. Khataturov was involved in the ground testing of one of the satellites. Its beacon was on the Moscow University building and he worked with it from his apartment. He said that the sensitivity of the Soviet relay was higher than the OSCAR satellite and allowed low power stations to work with them. He cited the fact that all Soviet HF stations, regardless of licence class, have an output power of only five watts. This is quite sufficient providing that the proper aerials are used.

The Soviets say that the 145 MHz band employed by the satellites "does not usually allow long distance QSO's.... Distances of 600 to over 1,000 miles are seen as record distances on this band.... only if propagation and other conditions are perfect. The satellites.... extend the (DX-ers') operations by thousands of miles."

Radio hams using the Radio 1 and 2 satellites are asked to "make sure that the power of the signal beamed by your station does not exceed the power of the signal beamed by either of the satellites' beacons. This is the easiest way to control power to within working limits.... The satellites provide for simultaneous work of 20 ground stations.... if the operational power does not exceed (the power load).... otherwise a significant overload occurs." The power of the transmitter used is only 70 milliwatts, "equivalent to a pocket torch."

By 18 November the Soviet DX programme on Radio Moscow was saying that the satellites "are at present active on Saturdays, Sundays and Wednesdays." Wednesday was reserved for scientific experiments and educational training. Again the warning was given not to exceed 100 milliwatts low power signal, (or) "the satellites may automatically switch off."

IRAS PROGRESS

Design and development activities relating to the IRAS project, a Dutch-American-British (NIVR-NASA-SRC) cooperation programme for the launch of an astronomical satellite which is to make an inventory of infra-red sources in space, was completed late last year. The Industrial Consortium IRAS (consisting of the Dutch companies Fokker-VFW and Hollandse Signaalapparaten) has now started to plan hardware production for the IRAS flight model.

Last year the Consortium made and tested development models of the various subsystems to be housed in the service module, the lower part of the satellite which is the responsibility of the Netherlands in this multi-national project. Extensive tests at systems level are now in progress involving a number of test models.

Fokker-VFW, having completed the Structural Model (SM), have sent it to ESTEC, the European space test centre. The SM consists of a model of the service module with a launcher attach fitting underneath it and a steel cylinder on top, simulating the weight and mass of the telescope system. During November 1978 the SM underwent vibration tests at ESTEC to study the mechanical stresses the satellite will have to withstand during launch. Fokker-VFW have since

assembled a Thermal Model (TM) of the service module. This model closely resembles the actual flight unit, the exterior being covered with coatings and thermal blankets. The upper part of the TM – the telescope section – is not built accurately to size but is designed to permit simulation of the heat development to be expected in this structure.

As from January the TM has been exposed to "space conditions" in ESTEC's large vacuum room with Sun simulator, to verify the IRAS thermal control system.

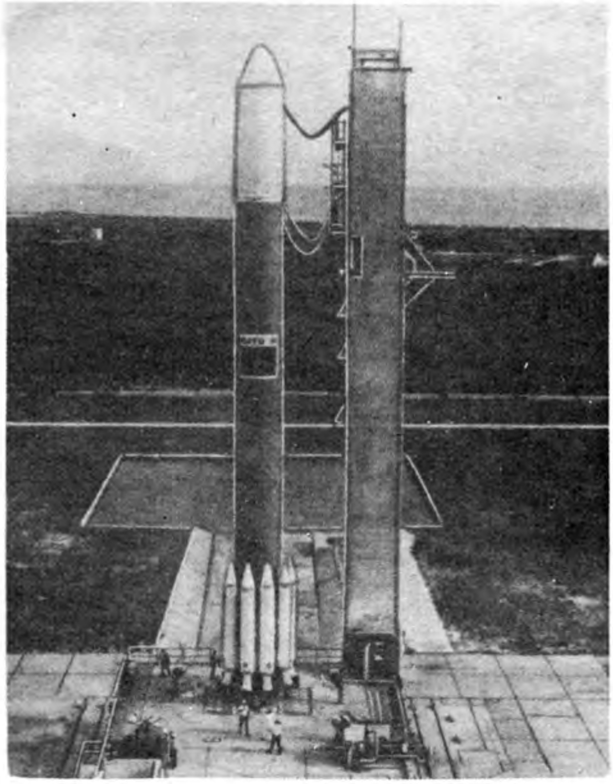
The Dutch National Aerospace Laboratory started integration of the Attitude Control Model in December. This ACM is currently being tested on a single-axis table to check whether the IRAS attitude control systems meets the design objectives. Electrical models of various subsystems such as the on-board computer, energy distribution system, telemetry and radio system and several other electronic devices, have been produced by Hollandse Signaalapparaten. Following mechanical and thermal tests, integration into an Electrical Model began in December. With the aid of this model, electrical operation of all subsystems together can be verified.

In the Netherlands some 250 people are now actively involved in the IRAS project.

Ball Aerospace Systems Division in the United States is in the process of manufacturing a Cryogenic Development Model of the Dewar vessel, the container which will cool the infra-red telescope system. In December representatives of NIVR, NASA and industry held a Critical Design Review of the telescope system in the United States.

At the Appleton Laboratories at Slough, England, a new antenna has been put up and ground equipment is being installed with which IRAS flight operations will be carried out after launch in 1981.

In recent months good progress has also been made in the field of software, the sophisticated computer programs necessary to enable IRAS to operate successfully.



ONE FOR NATO. Delta 146 stands ready for launch of the NATO III-C communications satellite from Complex 17 at Cape Canaveral Air Force Station. The 1,554 lb (705 kg) satellite, launched on 19 November 1978, subsequently was manoeuvred into geostationary orbit above the equatorial Atlantic.

National Aeronautics and Space Administration

IMPROVED LANDSAT

NASA's Landsat-D Earth-resources satellite is to fly a wide-band communications system built by TRW. The satellite, to be launched in the fall of 1981, will supply pictures for surveys of crops, vegetation, water resources, oil and minerals.

Landsat-D is the fourth in a series of experimental satellites designed to explore the Earth from more than 640 km (398 miles). In addition to the multi-spectral scanner (MSS) carried by the first three Landsats, Landsat-D will carry a sensor known as the thermic mapper (TM) which will provide a spatial resolution some three times as detailed as before.

The new sensor will be able to discriminate area features as small as 0.2 acres IFOV as compared to the 1.2 acre IFOV resolution of present systems. IFOV is a technical designation for instantaneous field of view. Improved spatial resolution, along with the narrower, task-oriented spectral bands, will enable the users to extract much more detailed and timely information.

The General Electric Company's Space Division of Philadelphia recently received a $77 million contract to build Landsat-D. The incentive contract cost includes a $5 million fee with additional earnings of up to $4.3 million depending on how well the system performs once the satellite is in orbit.

The contract also calls for a backup spacecraft; a data management system; an operations control centre to be located at the NASA Goddard Space Flight Center, Greenbelt, Maryland; a transportable ground station; and a Landsat assessment system to quantify and demonstrate the advantages of the thermic mapper over the MSS.

Landsat data is primarily used for the monitoring and management of food and fibre resources, water resources, mineral and petroleum explorations and land cover and land use mapping.

The Landsat-D instruments and mission-unique equipment will be installed aboard a Multi-mission Modular Spacecraft (MMS), a general purpose Earth-orbiting satellite bus which is being developed by NASA to supply the basic functions of power, propulsion, attitude control, communications and data handling as well as the structure to accommodate a broad range of scientific and applications-type payloads. The MMS will be designed to be retrievable by the Space Shuttle.

Certain additional mission-unique equipment required by the Landsat-D mission and not furnished by NASA with the NMS are: the solar array and its drive mechanism. Tracking and Data Relay Satellite System (TDRSS) antenna, a wide band communications module and a global positioning system. The mission will utilize the TDRSS at Ku band to relay payload information to the ground station at White Sands, New Mexico. In addition, direct transmission to the ground of wide band data at X-band and S-band (MSS only) will provide direct readout of Landsat-D data by foreign ground stations.

The TM and MSS data will be recorded at the TDRSS ground station and transmitted *via* Comsat satellites to the GSFC for preprocessing.

SOCIETY NEWS

30TH I.A.F. CONGRESS

"Space Developments for the Future of Mankind" is the theme of the 30th Congress of the International Astronautical Federation which will be held in Munich, West Germany, from 16 to 23 September 1979. It will also provide the background for the 10th IAF Invited Lecture, to be followed by a Forum session on "Mission Models and Space Planning" with a panel of leading international space specialists and audience participation.

The Congress programme will feature symposia on "Space Transportation Systems"; "Manned Operations in Space" and "Application Satellites." In addition there will be symposia of the International Academy of Sciences, the annual colloquium of the International Institute of Space Law, and the 9th IAF International Student Conference.

The Congress is being held upon the invitation of the Deutsche Gesellschaft für Luft-und Raumfahrt and co-sponsored by the Hermann-Oberth-Gesellschaft. It is open to participants from all nations.

The sessions for which papers are being solicited are as follows:

A. SYMPOSIUM "SPACE TRANSPORTATION SYSTEMS"

Propulsion Systems and Technology (three sessions) – Mixed mode and ultra-high chamber pressure chemical propulsion. High energy propellants (radicals, excited states, etc.). Airbreathing rocket combinations. High thrust ion and plasma propulsion. Advanced auxiliary propulsion including field emission and pulsed plasma thrusters. Nuclear thermal propulsion and inertially confined fusion. Laser propulsion. Waste utilization for propulsion (bio-waste, nuclear waste, pellet launchers, etc.).

Current and Future Launcher Systems (one session) – State of projects in USA, USSR, Europe, Japan, India, China, etc. Proposed advances and improvements. Next generation launchers including SSTO and heavy lift vehicles. Launch facilities.

Orbital Transfer Vehicles (one session) – OTVs and kick-stages for Shuttle and expendable launchers. Solids *versus* liquids. Cryogenic OTV propulsion including LOX/hydrogen and fluorine/hydrazine. Logistics of OTV launch from Shuttle. Propulsion platforms.

Atmospheric Vehicles (one session) – Bouyant systems, gliders, parachutes and aircraft in planetary atmospheres. Re-entry vehicles. Recovery systems for stages, orbiters and payloads.

Cost Reduction in Space Operations (one session, part of the 9th IAA International Symposium on Space Economics and Benefits) – Increased economy of space transportation systems and spacecraft by cost-optimization of size, staging, propulsion, trajectory and over-all system.

B. SYMPOSIUM "MANNED OPERATIONS IN SPACE"

Space Processing (two sessions) – Results of recent experiments. Status and future of space processing programmes. Hardware elements flown in sounding rockets and space missions. Elements under development or studied for future advanced missions.

Bioastronautics (three sessions)

1. *Adaptation and readaptation of living systems in space flight.*

2. *Biotechnology.*

3. *The Clinical Aspects of Space Flights* – Emergency treatment in space stations. Diseases likely to benefit by treatment under conditions specific to space. Health disorders likely to get worse under the same conditions.

Large Space Structures (one session) – Construction and building of large structures. Extravehicular activities. The role of astronauts in construction, maintenance and refurbishment of large space stations. Engineering problems including cost effectiveness of operations.

Advanced Systems (one session) – Large manned space stations, colonies, manned planetary and lunar missions, extraterrestrial mining and resources.

Space Rescue and Safety (one session, part of the 12th IAA International Space Rescue and Safety Symposium). Challenges incident to future activities. Avoidance of errors, injury and damage during the construction, maintenance and refurbishment of large space structures, including extravehicular activities.

C. SYMPOSIUM "APPLICATION SATELLITES"

Earth and Observations (three sessions).

1. *Theory* – Theoretical analysis of boundary value problems modifying the signals received by the systems. Problems of wave-propagation.

2. *Sensors and Systems* – Passive and active microwave systems from 200 to 300-GHz. Present and future development of radiometers for temperature, salinity, rain, moisture, etc. determination. Pulsed and special synthetic aperture radars for special observations (waves, snow, etc.) and their required system and design parameters.

3. *Applications* – Special applications for Earth and ocean observations with active and passive systems. Results and experimental data. Studies covering ground truth and air, ship, and space-borne experiments.

Communication Satellites (three sessions) – Potentialities of new applications, e.g.: many small low-cost terminals, high speed data transmission.

1. *Operational Systems* – Systems in operation or very advanced state of implementation.

2. *Experimental Systems and Institutional Arrangements* – Contributions on experimental systems, not just satellites. Emphasis on presentation of results of existing systems rather than descriptions of experiments.

3. *Future Systems and Technology* – Systems and technologies already in an advanced stage of definition. Future technologies presented should be of fundamental nature for the conception, not just accessory.

D. Other Sessions

Scientific Spacecraft (two sessions) – Systems for current and future missions. Vehicles and supports for advanced scientific missions. Semi- or fully automatic systems. New scientific orientations made possible by technological advances foreseen for the next decades.

Unmanned Solar System Exploration (two sessions) – Systems for current and future missions. Results of current missions. Problems of extremely long duration missions to the outer Solar System. Planetary exploration with rovers, penetrators, robots.

Power Systems for Space (one session) – The theory and technology of power systems for users in space – present and future.

Satellite Power Stations for Earth (one session) – The use of energy in space for utility power needs on Earth.

Astrodynamics (two sessions)

1. *Trajectories (natural or optimal).* Interactive trajectory and mission planning, cost reduction in orbit calculations.

2. *Natural or Controlled Motion Around the Center of Mass.* Subsatellite trajectories, drag free systems, etc.

Fluid Dynamics (one session) – Satellite aerodynamics, gas-surface interaction, electric charging. New methods of heat flow reduction during atmospheric entry. Hypersonic ionospheric flight.

Materials and Structures (one session) – Materials for large structures, thermostable structures. Problems of outgassing, UV-resistance, coatings. Prefabrication as opposed to *in situ* processing.

Applications for Large Structures in Space (one session) – Large space structures, technical and economical aspects. Complex high-quality systems in space as complement of cheap ground segments. Communication stations, antenna-farms, mission analyses, feasibility studies, etc.

The Influence of Space Technology on the Humanities (one session) – Aspects of effects of space activities on humanistic endeavours. Past and present effects on traditional and popular cultures. Long range impact of space technology on human culture.

Supervision of Youth Rocket Experiments (one session)

9th I.A.F. STUDENT CONFERENCE (two sessions) – Only student papers will be presented at the Conference. They should deal with space related experiments on research and **must be submitted through a Member Society of the I.A.F.**

Co-Ordinator: J. J. Irons
American Institute of Aeronautics and Astronautics,
1290 Avenue of the Americas,
New York, N.Y. 10019, USA.

SYMPOSIA OF THE INTERNATIONAL ACADEMY OF ASTRONAUTICS (I.A.A.)

9th International Symposium on Space Economics and Benefits (two sessions)

1. *Cost Reduction in Space Operations.* Symposium on "Space-Transportation Systems."

2. *Socio-Economic Benefits of Space Operations* – Diagnostic-predictive, early warning and other assistance that can be provided by space systems for on-Earth disasters.

12th International Space Rescue and Safety Symposium (two sessions)

1. *Space Rescue and Safety*, see Symposium on "Manned Space Operations".

2. *Worldwide Disaster and Rescue Response Employing Space-Borne Systems* – Employment of space-borne system in worldwide response in situations threatening or resulting from natural or man-made disasters.

8th International Review Meeting on Communication with Extra-Terrestrial Intelligence (CETI) (two sessions).

6th International Space Relativity Symposium (one session).

13th International History of Astronautics Symposium (one session) – New contributions to the historical literature on research in rocket technology and astronautics initiated before 1959.

Scientific-Legal Round Table on Large Systems in Space: Problems and Prospects (one session).

COLLOQUIUM OF THE INTERNATIONAL INSTITUTE OF SPACE LAW (I.I.S.L.)

22nd International Colloquium on the Law of Outer Space (four sessions) – Subjects have been chosen in consideration of the future work of the UN Outer Space Committee and should be treated (insofar as possible) in the light of the Congress theme:

1. *Energy and Outer Space* – new developments in space and their legal implications.

2. *Telecommunications* – special attention to be paid to problems connected with multi-antenna usage.

3. *International Space Flight* – status and related legal problems.

4. *Miscellaneous subjects.*

Organiser: Dr. K. H. Bockstiegel,
Director,
Institute of Air & Space Law,
Albertus Magnus Platz,
5 Cologne 41, FRG.

Members of the Society interested in presenting papers at this important Congress can obtain further information on writing to Mr. L. J. Carter, Executive Secretary, British Interplanetary Society, 12 Bessborough Gardens, London, SW1V 2JJ. (From 1 May onwards enquiries should be addressed to our new offices at 27/29 South Lambeth Road, London, SW8 1SZ).

Names of the International Programme Committee for the 30th IAF Congress will be found on page 185 of this issue. Ed.

THE SALYUT 6 SPACE STATION

By Neville Kidger

Positions of the major scientific installations and other science-related equipment on the Soviet Union's Salyut 6 orbital scientific laboratory are illustrated in this cutaway drawing of the station, redrawn from an original published in the Soviet Press. Also well shown is the major redesign of the engine system (ODU) carried out to the original Salyut design to accommodate a second docking port in the rear end of the station. This second docking unit can accept two types of spacecraft, the manned Soyuz and the automatic cargo/tanker spacecraft Progress. The second unit also serves as the interface for the Progress refuelling system which regularly replenishes the fuel tanks for the ODU. The Soviet Union has indicated that with regular refuelling missions flown by the Progress series of spacecraft the station can remain in use for up to five years. The standard number of crewmen for the Salyut 6 station is two, increasing for short periods of time during international flights to four. The Soviets have indicated, however, that the station is capable of supporting six cosmonauts.

Weights and Measures

The Soviets have not, at the time of writing, released detailed weights for either the Salyut 6 station or the Soyuz spacecraft being used in conjunction with it. Nor have they given accurate dimensions for either the station, Soyuz or Progress. The only reference that the author can verify from official sources are that the Salyut/2 Soyuz spacecraft assembly weighs "about 32 tonnes" and the length "about 30 metres." The Salyut station itself is described as "more than 13 metres in length."

During the periods of the Intercosmos manned flights to Salyut 6 the Intercosmonauts own countries have released "detailed" weights and dimensions for the assembly. This has resulted in an absolute plethora of unconfirmed, and mainly contradictory, data. In order to come to a reasonable, and hopefully, accurate set of data the author has sifted the available data from Soviet, Czechoslovak, Polish, German and even US sources.

The Salyut 6 station has retained the basic Salyut structure with the exception of the modifications to the aggregate, or engine, section. In describing the station I shall start from the Forward Transfer Compartment.

Forward Transfer Compartment

This three metre long compartment contains the forward, standard docking unit and an inner bulkhead which allows the cosmonauts to seal themselves in, away from the main section of the Salyut, but with access to the Soyuz and for EVA's. For EVA's the cosmonauts use a specially designed hatch cut in the side of the Salyut for exit into raw space. First use of this hatch was during the 2 hour 5 minute EVA conducted on 29 July 1978 by Vladimir Kovalyonok and Aleksander Ivanchenkov. Earlier in the Salyut 6 mission cosmonauts Yuri Romanenko and Georgi Grechko had depressurised the compartment and opened the docking unit hatch to examine the docking ring after the abortive Soyuz 25 docking attempt; that crew (Kovalyonok and Ryumin) had been unable to achieve a hard docking following a successful rendezvous and initial 'capture' on the docking unit.

The compartment also serves as the storage area for the two spacesuits (these are common to all flights and are adjustable in height for the various wearers).

Working Compartment

This section is the main living and working area of the station and comprises two connected cylinders with a total length of 9.1 metres. The compartment's small (2.9 m diameter) cylinder houses the main control panel for orientation and control of the station, rotation mechanisms and for the three batteries of solar panels mounted on its exterior and the main oxygen and life-support systems storage. It is connected to the main working area by a conec cylinder 1.2 metres in length. This section appears to house much of the station's electronics.

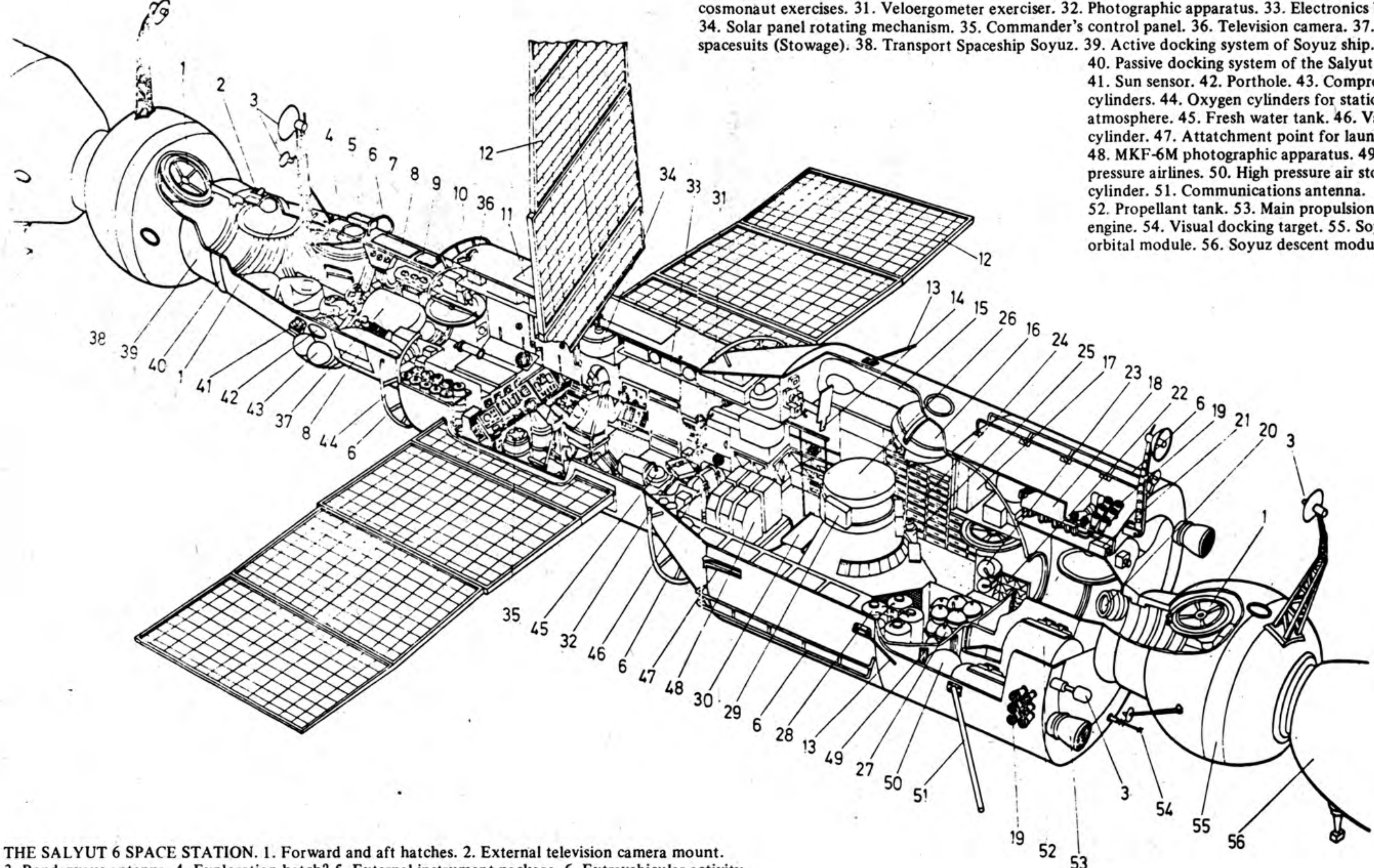
The large (4.15 metre diameter) cylinder houses the station's major scientific and medical equipment, including the cosmonauts' "mini-gym" comprising a treadmill, 90 cm long, 40 cm wide, and the velo-ergometer (stationary bicycle). The large diameter cylinder is dominated by the 650 kg BST-1M submillimetre telescope and the MKF-6M multi-spectral camera. Above the cosmonauts' heads are two spherical airlocks for ejection of unwanted small items and sanitation bags into space. The cylinder also contains the polythene erectable shower, food lockers, dining table, mass measurement device, fresh water containers, sleeping bag stowage and toilet amongst other items.

Rear Transfer Compartment and O.D.U.

On the previous civilian scientific Salyut space stations (1 and 4 and presumably the unsuccessful Salyut/Cosmos 557) the third section has been a 2.17 metre long by 2.2 metre diameter module which was solely an engine section, utilising the standard Soyuz engine, and additional small clusters of attitude control jets arranged around its exterior. On Salyut 6 this section has been completely redesigned to accommodate the second docking port. The section has been widened to the same 4.15 metre diameter as the large working compartment cylinder, although scaling of the Soviet drawing and attempting to reconcile figures from Eastern European sources leads to the conclusion that the section's length is only about 1.4 metres. Certainly all of the welcoming ceremonies for the international crews and the first all-Soviet triple docking appear to have taken place in the *Soyuz* Orbital module, usually seen through the aft transfer tunnel and thus confirming its short length. Polish and Czechoslovakian data have given the length as 3 metres although the length of the Working Compartment has been altered to only 7.5 metres to accommodate and reconcile the figures for the total length of the Salyut, which is quoted as being 13.5 metres, i.e. they have assumed the rear Transfer Compartment to be the same length as the Forward one and deducted whatever length was needed to satisfy that length requirement from the Working Compartment. The author considers that the 13.5 metre total length for the Salyut station is correct although confirmation of this is unavailable in exact form yet from a Soviet source.

In order to prolong the working life of the station, which on the earlier Salyuts was dictated by the amount of on-board fuel carried for the attitude control engines, the Soviet Union has redesigned the complete Salyut engine system and the fuel supply system. Both the main engine (a two nozzle arrangement one on each side of the aft docking unit) and the attitude control engine (comprising four clusters of multi-chamber thrusters spaced at 90° around the edge of the 4.15 metre diameter module) use the same fuel and oxidiser from the same tanks. The engine designers have also switched from the Salyut's previous turbine-driven engines to a simpler and more effective pressure-fed system. Thrusts for the new engines have not yet been announced. The refuelling technique is described later in this report.

Key continued. 20. Air Ventilator. 21. Television camera for aft docking operations. 22. Sanitary facilities. 23. Toilet. 24. Food lockers. 25. Sighting device (12 x magnification, for aligning the BST-1M telescope). 26. Container for scientific instruments (BST-1M telescope). 27. Fresh water storage. 28. Garbage containers. 29. Electronic control panels for instrument module. 30. Running track for cosmonaut exercises. 31. Veloergometer exerciser. 32. Photographic apparatus. 33. Electronics bay. 34. Solar panel rotating mechanism. 35. Commander's control panel. 36. Television camera. 37. EVA spacesuits (Stowage). 38. Transport Spaceship Soyuz. 39. Active docking system of Soyuz ship. 40. Passive docking system of the Salyut station. 41. Sun sensor. 42. Porthole. 43. Compressed air cylinders. 44. Oxygen cylinders for station's atmosphere. 45. Fresh water tank. 46. Vacuum cylinder. 47. Attatchment point for launch shroud. 48. MKF-6M photographic apparatus. 49. High pressure airlines. 50. High pressure air storage cylinder. 51. Communications antenna. 52. Propellant tank. 53. Main propulsion system engine. 54. Visual docking target. 55. Soyuz orbital module. 56. Soyuz descent module.



THE SALYUT 6 SPACE STATION. 1. Forward and aft hatches. 2. External television camera mount. 3. Rendezvous antenna. 4. Exploration hatch? 5. External instrument package. 6. Extravehicular activity handrails. 7. Airlock pneumatic controls. 8. External thermal control panel. 9. Airlock controls. 10. Sun sensor. 11. Protective screen. 12. Rotating solar arrays. 13. Telemetry antennae. 14. Zero-gravity cosmonaut weighing scale. 15. Sleeping berth. 16. Airlock for debris ejection. 17. Dust filter. 18. Pneumatic and hydraulic systems for attitude control and main propulsion engines. 19. Attitude control engines.

Drawings are adapted from original Soviet material. We should particularly like to acknowledge the Novosti Press Agency, 'Aviatsiya i Kosmonavtika' and the Czechoslovakian publication 'I. & K'.

Soyuz

The basic Soyuz spacecraft has been improved over the years and the current Soyuz ferry spacecraft, used since Soyuz 12, does not have solar panels for its 1.5 days of autonomous flight to and from the space station. The latest Soyuz spacecraft used on the Salyut 6 mission appears to have incorporated at least some of the design modifications first made on the Soyuz 16 ASTP spacecraft. The Czechoslovaks and Germans have announced that the weight of their inter-Soyuz spacecraft was 6800 kg, i.e. the same as the Soyuz 19 ASTP ship. Czech and German data are in basic agreement as to the other parameters of the Soyuz craft used for the Intercosmos flights; these are length 7.50 metres; maximum diameter 2.72 metres; volume of Orbital section 6.5 m^3; volume of Descent section 3.8 m^3. The volume of the Salyut space station is given as 90 m^3, and together with two Soyuz 110 m^3.

Progress

The unmanned Progress cargo/tanker spacecraft weighs 7020 kg and is based on the Soyuz design, using the same basic launch vehicle. Soviet data indicates that the Progress is, "at 8 metres, longer than Soyuz." Polish data on the unmanned ship is, however, more detailed and seems, to the author at least, to be more exact. These parameters are: length 7.94 metres; maximum diameter 2.7 metres; volume of orbital section (containing cargoes) 6.6 m^3.

Salyut Weight

The weight of the Salyut 6 space station has not yet been announced by the Soviets, but the Intercosmos countries have announced both individual weights and collective weights for the station and the two Soyuz assemblies. These are: Czechoslovakia and GDR, Salyut 18900 kg; with two Soyuz 32500 kg. Poland – 18800 kg and 32300 kg respectively. The author has no firm way of verifying these weights at the time of writing but the first set of figures can be expected to be, if not precise, at least within a couple of hundred kilogrammes either way. When the Soviets do announce the weight of the station it should be of interest to see if the weight is at the time of launch or after a refuelling and transfer of equipment from Progress. For their part the Poles have stated that every 16 revolutions of the Earth the Salyut 6/two Soyuz assembly loses 142 metres in altitude.

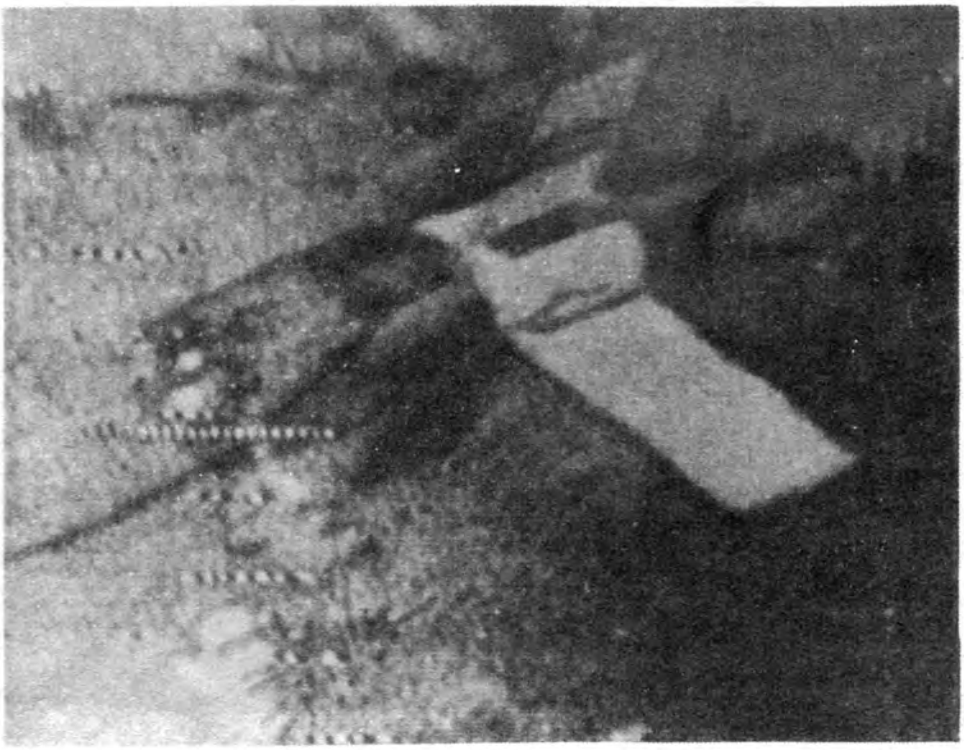
Solar Batteries

Salyut 6 has three panels of solar batteries, converting sunlight into electricity. They are mounted at 90° around the small diameter working compartment. The panels can be swivelled through 340°. The span from the tip of one panel to the tip of the opposite one is 17 metres. They have an area of 60 m^2 and produce 4 kilowatts of power. The telemetry antennae of the station return 2000 bits of data per second related to scientific and experimental functions. Soyuz returns about half that. Only 5-10% of the telemetered data is purely scientific.

General Observations

A major hardware addition to the Salyut 6 station was the provision, during the launch phase, of a protective shroud covering the entire forward working compartment and the transfer compartment, starting at the 4.15 metre diameter working compartment and terminating over the forward docking unit. Salyut 1 had a shroud which covered only the forward transfer compartment (on this station the solar panels, one set of two, were located on this section). It is thought likely that the new shroud, which covers the area of the repositioned solar panels, was introduced on Salyut 2, although the acknowledgement that Salyut 6 is protected by such a shroud is thought to be the first official confirmation of its existence. As its date of introduction is unknown its absence may well have accounted for the loss of the Salyut/Cosmos 557 civilian space station which failed almost immediately after orbital insertion in May 1973.

Other systems aboard the Salyut 6 have been improved from earlier stations. Thermal regulation and attitude control systems are installed in their final form on the station. On previous stations the cosmonauts spent up to 30% of their time preparing and carrying out orientation and course corrections. For orientation of the Salyut 6 station the cos-



TRANSFER DOCKING. Taken in the Control Centre at Kalinin, this photograph shows the manoeuvre performed on 7 September 1978 when Soyuz 31 with Vladimir Kovalyonok and Alexander Ivanchenkov on board, undocked from one end of Salyut 6 and then – after Salyut 6 had been turned through 180 deg – re-docked at the other end of the space station. This was the first time such a manoeuvre had been performed in space.

Panorama DDR/ Zentralbild

monauts rely on the Kaskad (Cascade) system, first tested on the Salyut 4 station. Kaskad uses a mathematical electronic memory and two sets of sensors evaluating heat and infrared radiation from the Earth, thus determining position with respect to the Earth's surface and ion sensors measuring the flow of "ionic wind" making it possible to determine the orientation of the station with respect to the direction of flight, its velocity vector. Gyroscopes are also employed in the Kaskad system.

The Delta navigation system uses the Salyut 2M onboard computer which continually reads parameters from the radio-altimeter, radial velocity meter and sunrise/sunset sensors. The system pinpoints the station's position within an accuracy of "from 2-3 km in longitude and latitude and up to several hundred metres in altitude. Delta is able to forecast the station's position more than 24 hours in advance. The Delta system is autonomous in operation to the extent of determining the orbital elements and being able to control the start and end of the communications sessions. All of the information gathered is stored permanently in the Salyut 2M's memory and can be recalled for display on the screen of the control panel or printed out on the Stroka teletype.

The life-support system used on Salyut 6 is, in principle, "the one that has already been used with the exception of the water regeneration system, recovering liquid from a condensor, which was considered experimental on Salyut 4, and is now working as an established piece of equipment; in the main it has to provide drinking water for the crew." The system collects moisture from the air, separates it from the gas mixture, purifies and decontaminates it, then mineralises it. No capacity has been given by the Soviets as to how much water can be recovered but each Progress transport has ferried "pure Moscow water" to the crew. This has allowed the designers to install a shower onboard. The shower cubicle is made from polythene and is collapsable. A cooling/drying cycle is used to separate the water from the station's atmosphere as the gas is passed through the first stage of the regeneration system, and the collected moisture is passed, *via* pumps, into storage columns containing ion exchange resins and activated charcoal for purification. The water is then passed through filters containing "fragmented dolomite, artificial silicates and salt." Special heaters based on conduction alone are used to heat the water, in the absence of convection in zero gravity conditions.

The interior colouring of the orbital station has been the work of a team of psychologists. They chose soft pastel colours to give the station interior a homely atmosphere. There is a "Cosy Corner" for leisure, a kitchen and a dining compartment.

Menu and Diet Changes

Thanks to the supplies of water from the Earth the cosmonauts onboard Salyut 6 have been able to enjoy a more varied menu and thus a better diet than previous crews of the earlier Salyut stations. A cosmonaut's calorie intake has been increased to about 3,000 per day. The men have a choice of 60 specially prepared meals and five different types of bread, specially prepared and cut into mouth-sized pieces. The food is prepared to last for up to 18 months. A typical day's menu for one crewman is detailed below:

Breakfast –	Tinned ham, white bread, cottage cheese with blackcurrant jam; cake, coffee and vitamin pills.
Dinner –	Vegetable soup with cheese and biscuits; tinned chicken; plums with nuts and vitamin pills.
Supper –	Tinned steak, black bread; cocoa with milk and fruit juice.

The cosmonauts have a different menu every day of the week and are allowed to substitute items if they tire of them. Although most items are in bite-sized pieces, enough for a single mouthful, some, notably the cottage cheese, soup, cocoa and the fruit juice are in tubes, as that form is considered the most convenient way of packaging the goods. Other items are coated with a special edible film to prevent the formation of crumbs, which are very difficult to control in weightless conditions. Some of the food is warmed on the onboard heating unit and most of the bite-sized pieces are made edible by adding water and kneading the food to a pasty consistency.

Vitamin pills are considered necessary because some of the food, being tinned, does not contain enough vitamins. The pills also are an aid for the very strenuous life the cosmonauts lead, with their large amount of work and exercise routines 2-3 times per day. The nutritionists, always looking to improve the diet, are studying what, if any, changes a cosmonaut's taste undergoes in prolonged flights. The equipment for this test is a small electrode that is clipped on to the cosmonaut's tongue and an electric shock is induced; the experiment, devised by Polish scientists is not considered the most popular on the flights. The nutritionists are also seeking ways to make the diet still more varied and "wholesome."

Noise Reduction

The internal sound insulation layer of the Salyut 6 station has been thickened by 50% to enable it to dampen most of the station's ambient noise; i.e., the hum of the ventilators, fans, motors and instrument functions. Cosmonauts who have worked on the Salyut have called it "noisy." Even when they sleep the cosmonauts say that they are subconsciously listening to this background noise to determine if the spacecraft is functioning correctly. The life-support system motors have been moved to the side of the Working Compartment in an endeavour to reduce this noise and many instruments have been muffled or muted.

Cosmonauts aboard Salyut carry individual dosimeters to monitor their irradiation doses and automatic measurements aboard the station are telemetered to the Earth to a special radiation warning group. In the event of a dangerous situation arising the warning group, who also get data from unmanned Cosmos satellites, would sound the alarm. Salyut's orbit and inclination were chosen, according to the Soviets, to take it through the safest part of terrestrial space, from the standpoint of radiation hazards.

Work Day in Space

The cosmonauts work day lasts, as a rule, from 0800 (Moscow time) to 2300 (MT) in order to conform to the men's biological "clocks" and as an aid to the Flight Control Centre at Kaliningrad, near Moscow. The programme of work in an average day is detailed below:

0800	wake, wash, shave, exercise.
0845	breakfast.
0945	begin work, medical checks, inspection of station's systems.
1045	mid-morning break.
1100	scientific work according to programme.
1230	lunch, rest, recreation.
1500	scientific work according to programme.
1630	tea-break

1700	scientific work according to programme.
1800	supper.
1900	work according to programme.
2300	bed.

'33.3% of the cosmonauts work time is spent observing the Earth, 33.3% is technological experiments, 16.6% on astronomical observations, 16.7% in biological and medical experiments and checkups.

Scientific Apparatus

Salyut 6 contains over 2 tonnes of equipment for scientific research in various fields including biology, astronomy, Earth resources survey, smelting metals, etc. The largest items of equipment are the BST-1M submillimeter telescope and the MKF-6M multi-spectral camera. These are described below:

BST-1M Submillimetre Telescope

The largest scientific instrument aboard the Salyut 6 station is a 650 kg telescope which measures radiation in the infrared, ultraviolet and submillimetre wavebands; actually the range covered is between 50-60 microns up to 1-2 mm. The externally mounted electron telescope has a concave reflector 1½ metres is diameter and is kept in a special compartment sealed off by a cover when not in use to protect it from solar radiation. The station is aligned in the general direction of the object being studied. The alignment is checked by a small optical telescope of 12X magnification by which fixes of known co-ordinates are taken. The cosmic radiation is focussed by means of the 1½ metre reflector dish onto semiconductor receiver crystals housed at the apex of the telescope.

The crystals are cooled to -269°, i.e. 4.2° above absolute zero, for accurate reception. In order to achieve this temperature the telescope is equipped with a closed-cycle cryogenic system weighing 130 kg which eliminates all "noise" in all electromagnetic ranges when the telescope is in use. When the receiver crystals are cooled to the extremely low temperature they acquire an ideal electromagnetic purity, radiating a minimum of their own "noise" at the atomic level.

The closed-cycle cryogenic cooling system consists of a compressor, a refrigerated machine providing the temperature of liquid nitrogen, a refrigerated machine providing the temperature of liquid hydrogen, a heat exchanger unit and a final heat exchanger unit with a throttle where the temperature of liquid helium is obtained. The detectors are located at this position. Production of the low temperature is a complex engineering achievement for the Salyut designers. The cycle starts when helium is introduced into the compressor, which compresses it to a pressure of 25 atmospheres. It is then passed to the heat exchanger where it is cooled by a counterstream and is then passed on to the first gas refrigerated machine which cools it to the temperature of liquid nitrogen. It then passes to the next heat exchanger, and then to the second refrigerated machine where it reaches a temperature of liquid hydrogen, i.e. 20-30 deg Kelvin. The helium next goes to the second heat exchanger and is cooled to about 7-10 degrees, from where it enters the final heat exchange unit with the throttle and is released from there with the temperature of liquid helium, about 4.2-4.5 degrees. It then goes back, cooling the counterstream and finally re-enters the compressor. The cycle takes about 1½ hours to complete.

The system consumes about 1.3-1.5 kW and its cold production is about 0.7 W. The thermodynamic coefficient is stated as being "good for this type of refrigerated system." The telescope has been used to examine the stars, galaxies, Earth's atmosphere and even a full lunar eclipse.

MKF-6M Multi-Spectral Camera Facility

During the Soyuz 22 flight in September 1976 the cosmonauts tested a camera, developed by scientists from the GDR, which takes photographs through six different filters. The camera was built at the Karl Zeiss works in Jena (GDR) as was the improved MKF-6M now operational on Salyut 6. The Soyuz 22 instrument was designed to work for only eight days in orbit, the Germans have said, whilst the MKF-6M unit aboard Salyut is designed to function for two years. The modified camera is able to withstand greater loads, up to 100 g, so that it is not damaged during docking, for example, when loads of 40 g may be experienced, or during launch of 5 g loads.

The MKF-6M operates in six bands of the electromagnetic spectrum. There are:

BAND 1 0.46-0.50 nm.	BAND 4 0.64-0.68 nm.
BAND 2 0.52-0.56 nm.	BAND 5 0.70-0.74 nm.
BAND 3 0.58-0.62 nm.	BAND 6 0.79-0.89 nm.

The image sharpness has been improved and the camera is capable of resolving objects on the ground of more than 20 metres. This can be compared with a resolution of 10 m on the MKF-6 camera flown on Soyuz 22. The difference in resolution is related to the orbital heights, Salyut 6 flies at between 340-350 km altitude, Soyuz 22 at 250 km. Photographs from Soyuz 22 (about 2,000 were returned) had a scale of 1:2 million, with an area of 115 x 165 km. Salyut's images are approximately 160 x 220 km. The individual film cassettes for the camera each carry enough film to photograph 10 million square km before film changes are required.

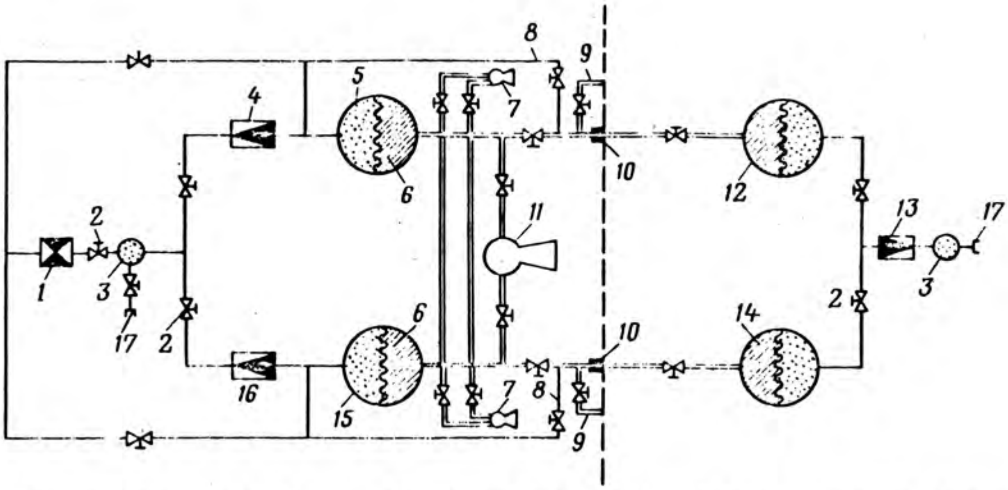
At the same time as the cosmonauts are taking photographs from space on selected passes over the same area photographs are taken from an AN 30 transport aircraft flying between 6,000 and 8,000 metres above the ground. The photos obtained on these flights cover an area of approximately 3.4 x 4 km. Simultaneously, on the ground, specialists take measurements of such things as the soil, humidity, crop ripeness, etc. Comparisons of observations from these three levels aids the analysis of the multi-zonal photos. The images are examined on another GDR-made Zeiss machine, the MSP-4 multi-zonal projector.

The Earth observations programme of the Salyut 6 station also uses other cameras including conventional and infrared films; a camera called the KT-140 is able to cover 200,000 km² on each frame. Stereographic images are produced by the camera.

Other Experimental Equipment

Onboard Salyut 6 are many other devices related to the experimental programmes envisaged for its lifetime in orbit. The first of these other items are the medical related experiments including the velo-ergometer, fixed to the ceiling of the lab, the treadmill and the 'Chibis' vacuum suit, consisting of perforated trousers made from elasticated rubberised cloth, which fits the body closely. In operation air is pumped out from under the covering of the vacuum suit, pressure is then exerted on the lower part of the body, making blood flow down to the legs, simulating to a certain extent the distribution of blood in the body as it would on Earth. The suit is used to exert a sense of gravity on the heart and leg muscles of the cosmonauts. The cosmonaut's weight is measured regularly on a scale, mounted on one of the Salyut's walls.

Other equipment was delivered to the station by the Progress transport ships, notably the two furnaces used to smelt metals and grow crystals. The two are Splav-01 (Alloy 0-1) and Kristall (Crystal) delivered by Progress 1 and 2 respectively. Splav-01 has three heat chambers, called the hot, cold and gradient areas respectively. The hot area is able



PROGRESS/SALYUT REFUELLING SYSTEM. 1. Compressor. 2. Valves and Vents. 3. High pressure sphere for forcing of fuels. 4. System for pumping and withdrawal of compressed air into and out of spherical tanks. 5. Tank for propellant (on Salyut, 1 of 3). 6. Partition. 7. Engines for minor movements. 8. Air lines to "blow-off" residual fuel from pipe lines. 9. Lines leading to exterior valves for venting residual fuels. 10. Hydraulic connectors for docking system pipe interface. 11. Engines for major movements. 12. Propellant tank (on Progress, 1 of 2). 13. As no. 4. 14. Oxidizer tank (on Progress, 1 of 2). 15. Oxidizer tank (on Salyut, 1 of 3). 16. As no. 4. 17. Tap for control of flow of compressed air.

to maintain a temperature of 1100°C which is controlled by a computer to within 5° of the required value. The furnace weighs 23 kg and uses 300 W when in use. Molybdenum reflectors inside the furnace concentrate the heat onto the sample and ensure that the temperature of the furnace wall does not exceed 40°C. One side of the furnace is connected, *via* a small airlock, to outer space to aid heat rejection and to enable the melting to occur in a vacuum. Samples are contained in capsules, each containing three crystal ampules that fuse when subjected to heating. Mono-crystals are formed in the gradient area and three-dimensional crystallisation is achieved in the hot and cold sections of the furnace.

The Kristall kiln is used to obtain semiconductor materials by the zone melting technique and also has been used to fuse optical glass.

Recreational Activities

For recreation on the very long duration space flights being conducted on the Salyut 6 station the Soviet psychologists have devoted much thought to the problem of maintaining the mental health of the cosmonauts. Recordings of concerts and films from the Earth are delivered to the crewmen by the Progress ships for use on the Salyut's onboard video-monitor, and other music is transmitted from the FCC for the crew's enjoyment. Once per week the crewmen's families are allowed to talk to them *via* the radio link. The working week is arranged deliberately to conform to Earth's accepted norm, i.e. five days work, two days rest. The station has on it books, music on cassettes and chess. Aleksander Ivanchenkov even had his guitar delivered by the Progress 3 transport craft. In order to relieve the boredom of the daily exercise routines, essential to maintain their physical condition, specially selected music has been piped to the crew. They reported that it worked to an extent. The experiment programme is also varied to stop repitition, although all of the cosmonauts have found the Earth observation programme to be the most interesting experiment.

Refuelling the Station

The major innovation on the Salyut 6 station is the capability to refuel the tanks of the ODU as regularly as necessary. As already mentioned the Salyut 6 ODU utilises a pressure-fed system of supply which necessitated design of an entirely new internal tanking and propellant fuel line system, the engines and the hypergolic thruster system for the station. Previous stations used a cold-fire hydrogen peroxide attitude control thruster-system. (See diagram, no's 1 and 2 for engines). The station has three fuel and three oxidiser tanks and the Progress tanker has two of each. The refuelling lines from the Progress to Salyut are located around the docking unit which serves as the interface for the refuelling lines. Progress can carry a maximum of one tonne of fuel and oxidiser to replenish the Salyut's tanks.

Nitrogen is used to pressurise the fuel system, stored in cylinders connected to the propellant tanks at a pressure of "about 200 atmospheres." The fuel and oxidiser tanks are divided internally by an accordian-type bladder in the middle, which is pressed against the internal wall of the tanks when they are full. The fuel flow is induced by pressure being introduced from the nitrogen bottles to push against the bladder, which expands and expels the fuel into the flow lines. A powerful compressor (3) reduces the nitrogen pressure in the Salyut tanks to three atmospheres.

The compressor has a 1 kW, three phase electric motor, powered by the direct current solar cell/battery electrical system *via* an alternating current converter. The compressor motors use a great deal of electricity putting a heavy drain on the Salyut power systems, so the preparations are staggered over six "shifts" to avoid affecting the operation of the other spacecraft systems.

The fuel aboard the Progress is stored at a pressure of 2½-3 atmospheres and is pumped aboard the Salyut at up to seven atmospheres. It is transferred first, followed the next day by the oxidiser. Following the transfer, nitrogen is used to purge remaining fuel from the transfer lines, so that no fuel or oxidiser is discharged in the vicinity of the space station during the Progress undocking operation.

Up to the end of the Soyuz 29/31 cosmonauts' flights the Salyut 6 space station had supported almost eight months of manned operation and had been in space for 13 months. If, as the Soviets claim, the station remains usable for the five year period they planned, it will house ever longer stays by cosmonaut teams being visited by Intercosmos crews with Soviet commanders and cosmonaut researchers from Hungary, Bulgaria, Mongolia, Romania and Cuba, currently training at Zvezdnoy Gorodok, for periods of about seven days.

SATELLITE DIGEST - 125

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed summary of the information presented can be found in the January,1979 issue, p. 41.

Continued from March issue]

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclination (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Cosmos 1047 1978-104A 11108	1978 Nov 15.49 13 days (R) 1978 Nov 28	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	170 168 169	352 327 354	72.88 72.85 72.87	89.77 89.49 89.78	Plesetsk A-2 USSR/USSR (1)
Cosmos 1048 1978-105A 11111	1978 Nov 16.91 100 years?	Cylinder? 750?	2 long? 1 dia?	785	813	74.04	100.89	Plesetsk C-1 USSR/USSR
NATO III C 1978-106A 11115	1978 Nov 19.03 indefinite	Cylinder 720?	2.2 long 2.2 dia	35495	35783	4.41	1428.5	ETR Delta NATO/NASA (2)
Cosmos 1049 1978-107A 11118	1978 Nov 21.50 13 days (R) 1978 Dec 4	Cylinder + sphere + cylinder-cone 6000?	6 long? 2.4 dia?	169 168	341 349	72.87 72.87	89.64 89.72	Plesetsk A-2 USSR/USSR (3)
Cosmos 1050 1978-108A 11121	1978 Nov 28.68 13 days (R) 1978 Dec 11	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2 dia?	255 223 173	278 284 332	62.82 62.80 62.83	89.93 89.58 89.56	Plesetsk A-2 USSR/USSR (4)
Cosmos 1051-1058 1978 109A-H 11128-11135	1978 Dec 5.76 10 000 years?	Spheroids? 40?	1.0 long? 0.8 dia?	1395 1411 1432 1447 1465 1471 1481 1479	1486 1489 1487 1490 1492 1506 1517 1540	74.02 74.02 74.03 74.02 74.02 74.02 74.02 74.02	114.73 114.93 115.14 115.34 115.55 115.78 116.01 116.25	Plesetsk C-1 USSR/USSR (5)
Cosmos 1059 1978-110A 11137	1978 Dec 7.65 13 days (R) 1978 Dec 20	Cylinder + sphere + cylinder-cone? 6000?	5 long? 2.4 dia?	178 168	336 371	62.78 62.83	89.64 89.90	Plesetsk A-2 USSR/USSR (6)
Cosmos 1060 1978-111A 11139	1978 Dec 8.40 13 days (R) 1978 Dec 21	Sphere + cylinder- cone? 5500?	5 long? 2.4 dia?	205	291	65.03	89.47	Tyuratam A-2 USSR/USSR
GPS 4 1978-112A 11141	1978 Dec 11.17 indefinite	Cylinder + 4 vanes 450?		20266 20183	20315 20288	63.27 63.29	722.39 720.14	ETR Atlas F DoD/USAF (7)
DSCS II (11) 1978-113A 11144	1978 Dec 14.03 indefinite	Cylinder 550	1.8 long 2.7 dia	35797	36412	2.49	1452.3	ETR Titan 3C DoD/USAF (8)
DSCS II (12) 1978-113B 11145	1978 Dec 14.03 indefinite	Cylinder 550	1.8 long 2.7 dia	36263	36416	2.50	1464.3	ETR Titan 3C DoD/USAF (8)
Cosmos 1061 1978-114A 11148	1978 Dec 14.64 13 days (R) 1978 Dec 27	Sphere + cylinder- cone? 5500?	5 long? 2.4 dia?	201	312	62.82	89.64	Plesetsk A-2 USSR/USSR
Cosmos 1062 1978-115A 11150	1978 Dec 15.56 5 years?	Cylinder? 700?	2 long? 1 dua?	503	548	74.0[illegible]	95.19	Plesetsk C-1 USSR/USSR
Telesat 4 1978-116A 11152	1978 Dec 16.01 indefinite	Cuboid + panels 900						ETR Delta Canada/NASA (9)
Cosmos 1063 1978-117A 11155	1978 Dec 19.07 60 years?	Cylinder + panels 2500?	5 long? 1.5 dia?	629	633	81.23	97.39	Plesetsk A-1 USSR/USSR
Horizont 1978-118A 11158	1978 Dec 19.51 indefinite	Cylinder + 2 paddles? 2000?	5 long? 2 dia?	23311	48952	10.69	1453.7	Tyuratam D-1-E USSR/USSR (10)

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Cosmos 1064 1978-119A 11161	1978 Dec 20.87 10 years?	Cylinder? 700?	2 long? 1 dia?	422	963	82.95	98.68	Plesetsk C-1 USSR/USSR
Cosmos 1065 1978-120A 11163	1978 Dec 22.91 2 years?	Ellipsoid? 550?	2 long? 1 dia?	345	549	50.68	93.46	Kapustin Yar C-1 USSR/USSR
Cosmos 1066 1978-121A 11165	1978 Dec 23.36 500 years?	Cylinder + 2 panels? 2000?	5 long? 1.5 dia?	822	895	81.24	102.18	Plesetsk A-1 USSR/USSR (11)
Cosmos 1067 1978-122A 11168	1978 Dec 26.56 2500 years?	Cylinder? 700?	2 long? 1 dia?	1161	1212	82.98	109.18	Plesetsk C-1 USSR/USSR
Cosmos 1068 1978-123A 11169	1978 Dec 26.65 13 days (R) 1979 Jan 8	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	176 169 166	389 297 363	62.80 62.80 62.80	90.15 89.16 89.80	Plesetsk A-2 USSR/USSR (12)
Cosmos 1069 1978-124A 11173	1978 Dec 28.69 13 days (R) 1979 Jan 10	Sphere + cylinder-cone? 5500?	5 long? 2.4 dia?	243	282	62.82	89.83	Plesetsk A-2 USSR/USSR

Supplementary notes:
(1) Orbital data are at 1978 Nov 15.5, Nov 23.0 and Nov 23.1.
(2) Third and final of a series of NATO communications satellites. The new satellite will provide back up services for the earlier ones.
(3) Orbital data are at 1978 Nov 21.6 and 1978 Nov 24.2. Two objects, one of which may be a redundant manoeuvring engine separated from Cosmos 1049 during 1978 Dec 3.
(4) Orbital data are at 1978 Nov 28.9, Dec 1.4 and Dec 6.4. An object which may be a redundant manoeuvring engine separated from Cosmos 1050 around 1978 Dec 10.
(5) Multiple launch of eight satellites possibly for military communication. One orbit is listed for each satellite.
(6) Orbital data are at 1978 Dec 8.8 and 1978 Dec 17.6. Two objects, one of which may be a redundant manoeuvring engine separated from Cosmos 1059 during 1978 Dec 19.
(7) Fourth satellite in the US military Global Positioning System. Orbital data are at 1978 Nov 14.2 and Dec 28.1.
(8) Pair of military communication satellites, to be located over the equator at 135° west and 175° east respectively.
(9) First of a new generation of Canadian domestic communications satellites. The vehicle will be operated at a position above the equator, longitude 109° east.
(10) Communications satellite for telephone and TV. Use of an inclined orbit gives better coverage for areas in the far north.
(11) Cosmos 1066 may be related to the Meteor weather satellites. Its orbital plane is very close to that of the third Meteor 2 (1977-117A).
(12) Orbital data are at 1978 Dec 26.9,1979 Jan 3.2 and 1979 Jan 5.4. Two objects, one of which may be a redundant manoeuvring engine separated 1979 Jan 6.

Amendments:
1977-102A, ISEE 1 – add a further orbit on 1978 Oct 29. Perigee; 1353 km, apogee; 139 946 km, inclination: 45.6 degrees, period 3442 min. ISEE 2 orbit has similar elements.
1978-85A, Cosmos 1031 – apogee on the first orbit listed should read 327 km.
1978-88A, Cosmos 1032 – period should read 88.92 min.
1978-95A, Molniya-3 (10) – add a third orbit at 1978 Oct 24.9. Perigee: 423 km, Apogee: 39925 km, period 717.65 min, inclination: 62.83 degrees.

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BOOK REVIEWS

Study of Travelling Interplanetary Phenomena, 1977
Editors, M. A. Shea, D. F. Smart, S. T. Wu, (Astrophysics and Space Science Library, Vol. 71), D. Reidel Publishing Co., 1977, pp. 440, US$38.

In 1973 an organization for the "Study of Travelling Interplanetary Phenomena" (STIP) was set up by the International Council of Scientific Unions' Special Committee on Solar-Terrestrial Physics, to bring together those scientists around the world interested in the study of the 'quiet' and 'disturbed' interplanetary medium, *viz.* the solar wind. This group, of about 200 participants, has organized several successful symposia in recent years and the present volume contains the invited review papers presented at the STIP symposium held in conjunction with the XX Cospar meeting in Tel Aviv, Israel, in June, 1977.

The solar wind in the vicinity of the Earth's orbit is observed to consist of a highly supersonic flow of protons, alpha particles and electrons blowing radially outwards from the Sun at speeds of ~ 400 Km s^{-1} and with a density of ~ 10 cm^{-3}. These typical numbers are, however, subject to strong systematic variations on time-scales ranging from a few minutes to several days. It is these disturbances, their solar origins and their propagation outwards into the solar system, which is the primary concern of STIP and hence of the contents of this book.

There are two principal causes of such variations in the solar wind, *viz.* (a) the "corotating interaction regions" which arise from the interaction of high and low speed solar wind streams originating from different areas on the Sun, and (b) solar flares, in which there is a large explosive release of solar magnetic energy stored in and near sunspot groups, resulting in large ejections of gas into the corona, the production of high-energy particles, and, if sufficient energy is released, outward travelling interplanetary blast waves. The latter is the more spectacular of these phenomena but the former is the more important for the overall dynamics of the solar wind, and is concentrated on more heavily in the book.

High-speed solar wind ($V > 600$ Km s^{-1}) appears to originate from regions on the Sun known as 'coronal holes', regions characterized by low plasma temperatures and/or densities near the base of the corona and by unipolar magnetic field lines which open out into interplanetary space. During the Skylab era these holes covered $\sim 20\%$ of the surface of the Sun, the majority of which was contained in two large "holes" surrounding the rotation poles. Longitudinal asymmetries in these polar holes or the appearance of secondary holes at lower solar latitudes result in the appearance of high-speed streams near to the ecliptic plane, where they are observed by spacecraft for several days as the hole rotates around on the Sun. The precise origin of low speed wind ($V \sim 350$ Km s^{-1}) is less certain; possibly the wind speed is reduced by some process near to coronal hole boundaries; alternatively, it is suggested in Axford's stimulating contribution that it may originate from a rather large and ill-defined region at lower solar latitudes in which the magnetic field connectivity changes sufficiently rapidly that equilibrium along a magnetic flux tube (*viz.* a high speed wind) is never achieved. If this suggestion is correct it implies that theoretical work on the solar wind, discussed in detail in Cuperman's review, which has attempted to model the *low-speed* wind as a radially symmetric equilibrium flow, has essentially been doing the wrong problem for the past twenty years. It will be interesting to watch future developments.

Be this as it may, the dynamics of the low-latitude wind is observed to be dominated by the interaction of high and low speed streams, and the book contains several interesting papers describing the evolution of such regions with distance from the Sun, out to the vicinity of Jupiter (~ 6 AU) as seen by Pioneers 10 and 11. At higher solar latitudes, however, these interaction regions are expected to disappear, giving way to continuous high speed wind from the polar holes. Direct measurements from this region will not be available, however, until the launch of the 'out-of-the-ecliptic' (OOE) spacecraft in ~ 1984, so that remote sending techniques must be exploited at present. The book contains several papers describing recent results obtained from the observation of scintillations in the signals from galactic or extragalactic radio sources, produced by their propagation through the solar wind. Unlike present spacecraft, these sources are not,of course, confined to the ecliptic plane, and the results on the variation of wind speed with latitude seem to confirm the above picture.

Remote techniques are also required to probe the region close to the Sun, where the intense solar radiation precludes direct spacecraft investigation. Recent results using radio signal scintillations from the Helios spacecraft are presented, and the analysis of the flare-associated mass ejections observed by the Skylab white-light coronagraph are reviewed. Comets can also be used as natural probes of this region, and the book contains three interesting papers on their properties, although the emphasis of each of these is on the problems in understanding cometary processes rather than their use as probes in the STIP context. Finally, the book concludes with a section devoted to the propagation of flare-produced energetic particles (solar cosmic rays) through the interplanetary medium, in which the modulation introduced by their interaction with the above-discussed interaction regions and with interplanetary shocks and waves is emphasized.

In summary, the book has been nicely produced from 'camera-ready' author-prepared typescripts, and although this leads to a degree of anarchy in the format of presentation, it also leads to the very rapid publication so essential if such conference proceedings are to be of use to the scientific community as anything other than just an historical record. In this rapidity the publishers are to be congratulated. The book will be of considerable interest to all those with a serious interest in the physics of the solar wind.

Dr. S. W. H. COWLEY

Discovering Astronomy
By R.D. Chapman, W.H. Freeman and Company Limited, 1978, pp 518. Soft cover £7.00, Hard cover £12.60.

The author, an employee of NASA, has written in the fashion (quote) "from the inside looking out". In other words, commencing with 'Our place in the universe' he covers the history of astronomy, telescopes, the Solar System and our Galaxy, to Black Holes, cosmology and interstellar communication.

The 16 chapters are a veritable mine of information with a few revision questions set at the end of each.

The author leads the reader from cover to cover in such an absorbing and progressive manner and easy-going style that a 16 year old with a mathematical bent would be able to cope with and be successful in an A level exam.

There are 463 descriptive figures, nearly half of which are photographs, including 8 colour plates, which make assimilation of the contents easy for the reader. The

figures are drawn clearly and easily understood in black and red and words of note in the astronomical vocabulary are in bold type. The printing and photographic work is of excellent quality. Distances in the text are in metric measurement. There are 6 appendices, including star charts, a glossary and an index. Mr. Chapman describes how and why in a few billion years the people in one hemisphere will never see the Moon and will have to take a vacation to do so! This is an example of interesting and absorbing but, at the same time, 'light' reading.

There is but one slight criticism: I could not find a table giving distances from the Earth to the planets. This may have been an intentional omission by the author in order to make the student use his grey matter. However, by the time one has read the book, been favoured with a clear night sky and used the 'Skinny Triangle' procedure,one will be able to calculate the missing measurements.

An excellent book for the beginner and a refresher for those in need. It is as up to date as it can be.

R. D. MILLAR

OSCAR – Amateur Radio Satellites
S. Caramanolis. Radio Society of Great Britain, pp. 192, 1978 £3.80.

It is difficult to say if this book is aimed at the radio amateur with little knowledge of radio techniques. It would be easy to fall between two stools but the author offers something to both groups. The translation from the original German comes over well but may account for the unexplained appearance of 50 Hz on p. 87 and the use of diffraction instead of refraction in Chapter 9.

The first two chapters are devoted to an elementary treatment of planetary and satellite orbits. Graphs and simple formulae are given for orbital height, period and speed but these are restricted to circular orbits and constant periods. The effect of the Earth's flattening on the rotation of the major axis of the orbit is mentioned but the effect on rotation of the orbital plane – a much more important consideration for near-circular orbits – is ignored throughout the book, making a nonsense of the use of four places of decimals in Chapter 8.

Chapter 3 deals with the structure of a satellite and the power supply, temperature and attitude control systems and the telemetry and telecommand systems. The following chapter, treating the satellite as a relay station, deals with the maximum communication range but, strangely, does not give a formula for calculating the ground station's radio horizon for a satellite at a given height. Fig. 40 is carelessly drawn, even if one ignores Earth-rotation, with successive ascending nodes being shown to occur 20° further east due to the use of a map projection covering 380° of longitude.

The author is more at home in the chapter on the fundamental of telecommunication *via* satellites. Formulae are given for free space loss, power budget and receiver sensitivity. There are good chapters on telemetry systems and on the first seven OSCAR satellites.

Chapter 8 on operating with amateur satellites covers the topics of transmitter power, receiver sensitivity and antenna gain. The section on arriving at ground-track diagrams is less good. The method for obtaining azimuth and elevation is probably satisfactory for radio communication with antennae of 15° beam-width but not sufficiently precise for visual look-angles.

The final chapter on the educational aspects of the OSCAR programme deals with Doppler analysis and the interpretation of telemetry. It looks forward to OSCAR 8 – now in orbit. Mention is made of Eichenauer's work on extended range reception due to overshoot by "diffraction" in the ionosphere and on SSTV meteorological images from a German station *via* OSCAR 7.

Members of the Society are recommended to read this book which will surely contain something for everyone.

GEOFFREY PERRY

New Instrumentation for Space Astronomy
(Eds.) van der Hucht, K. A. and Vaiana, G., Pergamon Press, 1978, pp. 339, £22.50.

For over twenty years now, astronomical observations have been performed from space vehicles. This has made previously unstudied wavelength regions accessible to observation, and led to new and sometimes startling results manifesting themselves. However, this initial survey phase of space astronomy is now nearly past and those original discoveries are being followed up with the use of increasingly sophisticated instrumentation. These instruments are primarily being designed by scientists who have grown up in the era of space astronomy. The publication of the proceedings of a symposium on the subject, sponsored by COSPAR and the IAU, appears, therefore, to be a timely contribution to the scientific literature.

The papers from the symposium are divided almost equally between the subjects of optical/ultraviolet and X- and γ-ray instruments, with surprisingly little mention of infra-red techniques. It is unfortunate that 10 of the papers are in abstract form only, especially as some of them appear particularly topical and important. There are some errors of spelling and grammar but this seems an acceptable price to pay for publication occurring relatively soon after the conference itself. The great strength of this book lies in its extensive coverage of much of the currently operational, and soon to be launched instruments for space astronomy. These include such diverse missions as HEAO-A, HEAO-B, IUE, SMM, OSO-8, Space Telescope and various Spacelab experiments. Anyone wishing to gain an understanding in some depth of current space astronomy instrumentation will therefore be well served by the scope of this book, and in particular by those contributions which contain a limited review of their respective topic. However, this does inevitably mean that some previously published material does appear in these proceedings. It is also interesting (and to be commended) that some mention is made of the absolute calibration of various instruments, most notably the Faint Object Camera for the Space Telescope, since this topic, though often neglected in the scientific literature, is of vital importance to the successful operation of any space instrument.

For those with a particular leaning toward the astronomical implications of this marvellous array of space hardware, there appear to be two main conclusions whichwe can draw from these contributions. First, it is apparent that the Space Telescope is likely to provide the greatest source of scientific information in optical astronomy through to the end of the century. Despite having a significantly smaller aperture than the largest existing ground-based telescopes, by rising above the atmosphere and throwing off the limitations imposed by it, the Space Telescope should enable us to see celestial objects at about 10 time higher spatial resolution than now possible and, furthermore, to reach far fainter objects than is currently feasible. For example, in an observation lasting 10 hours, it appears that it will be possible to detect a star of 28th magnitude – this is about 100 times fainter than the limiting magnitude currently accessible to ground-based telescopes. The implications for the improved understanding of individual classes of sources and, in particular, in the field of cosmology,are enormous.

The second feature of particular significance to emerge is in the field of X-ray astronomy. Up until recently, the majority of observations have been carried out with relatively low spatial resolution, resulting in rather poor quality images of X-ray sources. However, it is quite clear that great emphasis is now being placed on various types of X-ray imaging systems, usually based on grazing incidence reflection X-ray telescopes with a variety of instruments placed at the foci. Once such instruments are successfully placed in orbit, we shall soon be seeing 'X-ray pictures' with a resolution of a few seconds of arc, almost comparable with present day optical imagery.

This book, containing as it does a wealth of description of the present and future generations of space astronomy instrumentation, can be highly recommended both to those wishing to become acquainted with the interactions of the instrumentation itself, and, in addition, to anyone who might like to speculate as to what path astronomical observations from space vehicles may follow over the next decade.

DR. J. C. ZARNECKI

The New Cosmos
(2nd Edition) by A. Unsöld, Heidelberg Science Library, Springer Verlag, New York, Heidelberg and Berlin, 1977, pp. 451, $18.50.

This book is divided into three main parts entitled Classical Astronomy, Sun and Stars – astrophysics of individual stars – and Stellar Systems, Milky Way and Galaxies, Cosmogony and Cosmology. There are two pages of physical constants and astrophysical quantities, an 11 page chapter-by-chapter bibliography and an extensive 20 page index.

The author sees the book's most important task as giving a not-too-difficult introduction to present day astronomy and astrophysics, both to the student of astronomy and to the specialist from a neighbouring discipline. He says that amateur astronomers should not be frightened by a few formulae but should accept, at least at first, the numerical results to which they lead. Certainly the book is liberally sprinkled with formulae but the argument and discussion can be followed without examining each one. To derive the maximum from the book would take months of study as part of a course, but it is so well written, illustrated and set out that it is a pleasure to look up specific sections as the need arises. It is handy for reference because of good indexing and section titles, but it is more than just a reference book because it is written in such a clear and interesting way.

The first part covers historical ideas, celestial sphere, coordinates, seasons, time, the Earth's motion, Moon and eclipses. It includes mechanics and gravitation, physical aspects of the planets, satellites and minor bodies of the Solar System, and a chapter on instruments. Although the amount of space devoted to the physical aspects of comets, for example, is only three pages, the summary is remarkably informative. This first part of the book covers 104 pages.

The second section of 114 pages, deals with all aspects of the Sun and stars, their brightness, variability, spectra and so on, and with multiple stars and their masses.

The final part is the longest, at 190 pages, of which some 80 pages are devoted to the Milky Way, and the remainder with other galaxies and cosmological problems. Here we find detailed discussion of energy generation in stars, colour, magnitude, diagrams of clusters, stellar evolution, cosmic rays, evolution of galaxies and so on. Finally there are relatively short sections on the theories of the origin of the Solar System, the Universe and of life.

The New Cosmos is not a picture book but the photographs in the text are well chosen and adequately reproduced. Diagrams are numerous and very clearly drawn and have captions of sufficient length to make reference to the text unnecessary in order to understand them. The general quality of layout, printing and paper is high, making the volume a pleasure to handle.

The book is not expensive by today's standards and it can be thoroughly recommended for its authority, readability and usefulness for reference.

M. . . HENDRIE

At The Crossroads of Knowledge
By V. A. Firsoff, Ian Henry Publications, pp. 136, 1977 £3.95.

This book is a wide ranging interdisciplinary work in biology, chemistry, biochemistry, physics, astronomy, planetology, psychology and philosophy. Val Axel Firsoff has applied his considerable knowledge, with some intuition, to contemplate problems relating to the origin of life and its probable existence elsewhere in the Universe.

Initially the problem of distinguishing the living from the non-living is considered. The boundary line between these two states seems to be a matter of definition. The basic chemistry of life is then introduced, a rather difficult chapter to grasp unless the reader has some background knowledge of organic chemistry and biochemistry. It discusses the production of polymers leading to the development of amino acids and to the nucleic acids, ribonnucleic acid and deoxyribonucleic acid. Thus, the basic building blocks of life are formulated.

The necessary elements for biochemical evolution are available throughout the Universe. The development of life on Earth, initially in a reducing atmosphere and finally in an oxidizing atmosphere is discussed, and terrestrial limits to life then considered. It is truly amazing that life in some form has gained a foothold in almost every habitat on Earth.

Other planets with different environs may still support life as we know it. Our neighbouring planets are examined for possible survival of some life forms. Also some interesting theories of life based on alternative biochemistries are proposed. It is possible, for example, to replace carbon by silicon, nitrogen by phosphorus and oxygen by sulphur, and to design the building blocks of life in terms of these heavier elements. Such a biochemistry would be completely alien to us but, nevertheless, tenable.

The most controversial part of the book is undoubtedly the contention that 'mind' is an essential part of reality. Perhaps 'mind' may be regarded as a distinct and fundamental property of matter which is present throughout the Universe. This property may direct the basic building blocks of life into more complex structures, producing life of higher orders.

Finally it becomes clear that many planetary systems should exist throughout the Universe and life should be abundant.

Overall, I felt that the book lacked a certain cohesion, but contains many stimulating and controversial ideas. The author is never afraid to express his own opinions even if these oppose the concensus of scientific thought of the day. The reader will almost certainly disagree with some items in the book, but the author's ideas are thought provoking and not easily dismissed.

JOHN S. BURY

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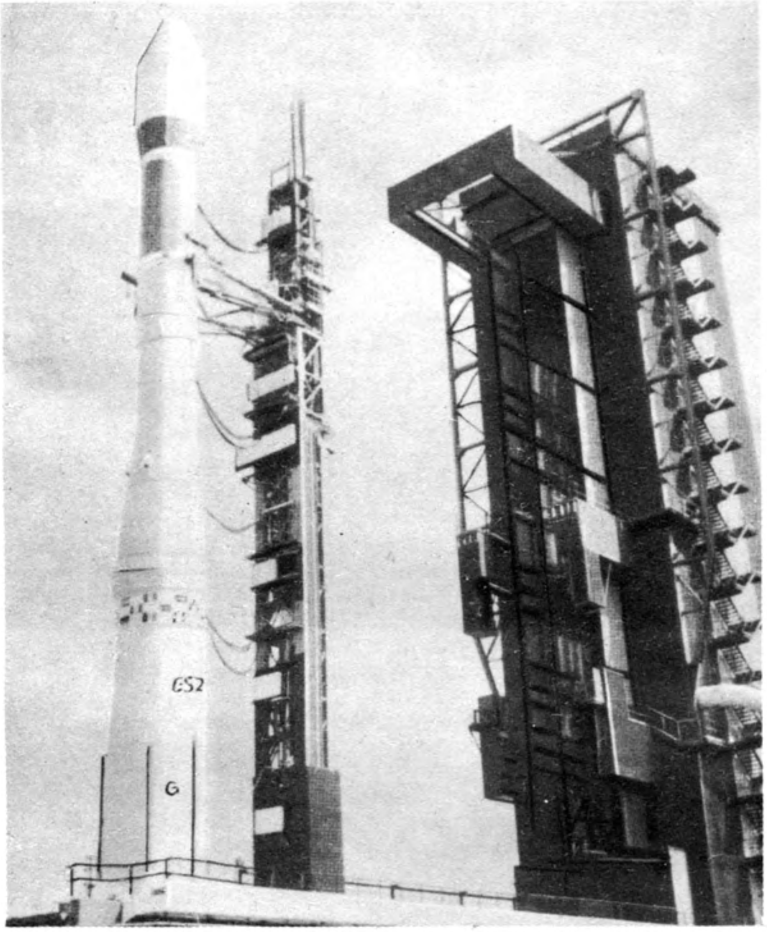
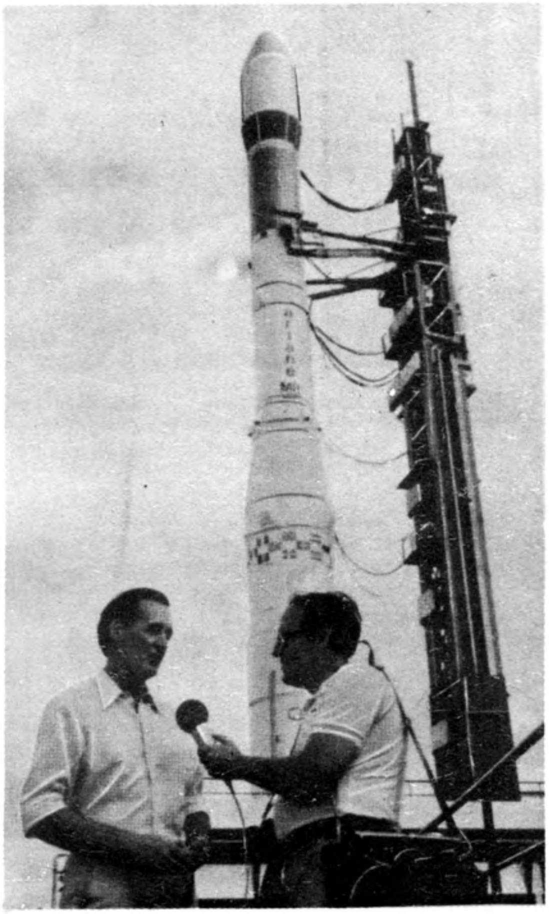
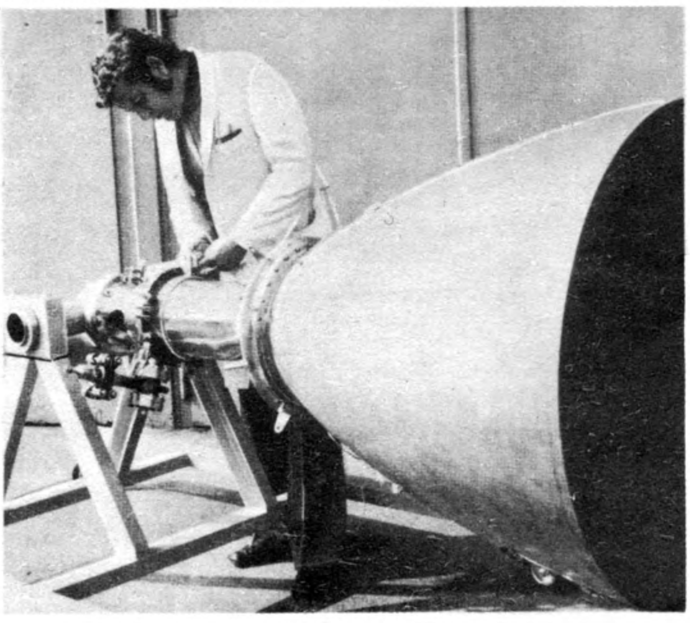
(спейсфлайт)
По подписке 1979 г.







VOLUME 21 No. 5 MAY 1979

Published by
The British Interplanetary Society

PRESENTATION OF PAPERS AT THE 30th IAF CONGRESS

Munich, Germany 17-22 September 1979

The Society is anxious to expand the attendance from the U.K. at international space meetings. Prime among these is the 30th IAF Congress, to be held this year in the Deutches Museum, Munich, from 17-22 September 1979.

A wide range of technical sessions will be held, as listed on page 179 of *Spaceflight* for April, as well as many social and other occasions.

Student Conference and Awards

Papers submitted to the IAF student Conference should meet the following requirements. If accepted for presentation at the Conference, they will compete for the awards offered by the IAF.

1. Authors must not be more than 28 years old and must be regularly enrolled at an educational institution. The age limit will apply to co-authors, if any, and to all members of a group if the work is presented as a group project.

2. Papers must be original and deal with work done as part of a student activity, not a professional one.

3. Papers by students should be submitted through an IAF member society, accompanied by a statement certifying that they meet the requirements under paragraphs 1 and 2 above.

4. The subject of papers should preferably fall within one of the topics selected for the technical sessions of the IAF Congress. Subjects related to other space systems, problems and activities, or suggesting a potential application to the future development of space activities may also be considered.

5. Authors of accepted papers will receive a special information sheet to be completed and returned to the IAF Secretariat in Paris, together with six copies of the full manuscript before 15 August. The manuscripts and information provided by the author will be needed by the IAF Jury to evaluate the papers.

6. Two first prizes and two second prizes will be given for papers authored and presented by students at the Student Conference. Certificates will be awarded. First prizes may be accompanied by a medal offered by a member society of the IAF.

7. The Jury will be comprised of the President of the IAF, the Chairman of the Student Activities Committee, the Chairman of the Education Committee, the Secretary of the Student Conference, and the President of the member society offering a medal (if any). In case of duplication of functions or resignation, the IAF President will designate another member of the appropriate Committee to serve on the jury. The jury may call in specialists to assist in reaching a decision. The Chairman of the Student Activities Committee will serve as Chairman of the Jury.

8. The Jury may decide not to award some of the prizes. *All decisions of the Jury will be final.*

9. The distribution of prizes will be made during the annual Congress of the IAF.

10. An effort should be made to type the student paper on the preprint forms that will be sent to each participant. If a student does not prepare a preprint, then the final report should be typed, not handwritten.

11. The presentation at the conference is to be 15 minutes long with an additional five minutes for questions.

12. 35 mm slides and overhead slides are the only acceptable audio visuals. A chalk board will be provided, but its use is recommended only for clarification of questions, not for part of the presentation.

13. English is the recommended language. If English is not a student's home language, and he/she gives the presentation and written report in English, the judges will not penalise the student.

Students who wish to present a paper at Munich are advised to send a letter of intent to Mr. Yann Kerr, Co-chairman of the 9th IAF Student Conference, The University, Glasgow, G12 8QQ.

BIS Development Programme

Grants from the Society to attend the 30th IAF Congress

Following the receipt of a £500 anonymous Donation to the A. V. Cleaver Memorial Fund the Society is in a position to offer grants of £50.00 each to assist up to a maximum of 10 Members, irrespective of membership grade, with their expenses in attending the 30th IAF Congress. In making these arrangements the Society has been mindful of the generosity of 'Val' Cleaver to others and to the encouragement he gave to people in all parts of the world in their efforts to further the development of astronautics.

Any Member from either the UK or overseas who was aged 18 years or over, having at least one year's Membership standing on 1st January 1979, is eligible to apply for a grant.

Application should be by letter, to reach the Executive Secretary by *15 July 1979,* and which should specifically state

(i) The year in which an IAF Congress was last attended.

(ii) Age on 1st January 1979.

(iii) Number of years of uninterrupted BIS Membership on 1st January 1979.

Applicants will be advised as soon as possible after 15 July 1979 whether or not a grant has been allocated.

Arrangements for payment of grants (in sterling), will be made at the Congress on application to The Executive Secretary or other appointed Society Representative.

A systematic procedure will be followed for the allocation of grants which is based on the details (i)-(iii) above. The decision of the Council in this matter shall be final.

Apply before 15 July 1979 to:

The Executive Secretary, The British Interplanetary Society Limited, 27/29 South Lambeth Road, London, SW8 1SZ, England.

Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

CONTENTS

COVER

EUROPEAN LAUNCHER. Late this year Western Europe expects to be back in the business of satellite launching when the first development round of the ESA Ariane is launched at the Guiana Space Centre, Kourou. *Top left,* engineering model of the three-stage rocket on the launch pad. *Right,* Mr. Roy Gibson, Director-General of the European Space Agency, is interviewed during the recent Press visit. *Below,* the HM7 liquid oxygen/liquid hydrogen thrust chamber which will power Ariane's third stage.

Photos: Theo Pirard and (bottom) Messerschmitt-Bölkow-Blohm

SPACEFLIGHT

A Publication of The British Interplanetary Society

VOLUME 21 NO. 5 MAY 1979 *Published 15 April 1979*

MILESTONES

January

25 NASA announces names of first four Space Shuttle orbiters to operate in space: Orbiter 102 is *Columbia*; Orbiter 099 *Challenger;* Orbiter 103 *Discovery*, and Orbiter 104 *Atlantis.* The first Orbiter constructed (101) was named *Enterprise* in 1976 after the flagship in the television series 'Star Trek'. All, however, are names of sea-going vessels of the past used in world exploration. (*'Columbia' will be the first Shuttlecraft to be launched into orbit. 'Enterprise', used for glide tests from a modified Boeing 747 and dynamic testing at Huntsville, will not fly in space. Ed.).*

25 Skylab space station is manoeuvred into an attitude that may allow some measure of control over the vehicle's re-entry into Earth's atmosphere. Station achieved a solar inertial attitude. In this new position, "the solar panels are constantly pointed toward the Sun, assuring full electrical power at all times, thereby preserving the possibility of some minimal influence on the final re-entry.

28 First Space Shuttle launch at Kennedy Space Center is re-scheduled to 9 November 1979 following 27 December engine failure during static testing. Secondary reason for delay is difficulty with the application of thermal protection tiles.

30 Reports from Moscow reveal that a Soviet Cosmonauts Federation has been set up to promote scientific and technological study of outer space. Federation, headed by cosmonaut Anatoli Filipchenko, aims "to unite scientists, designers, cosmonauts, writers and journalists to publicise developments in space exploration."

February

3 Revised etsimates for balloon life in highly-corrosive, sulphuric acid-laden atmosphere of Venus, made by Professor Jacques Blamont, reviewing latest findings of Pioneer-Venus mission, suggest that each balloon planned for 1984 Soviet Venera mission may last at planned altitude of 35 miles (56 km) only about six days (see *Spaceflight,* March 1979, p. 98). Most difficult problem is adhesives to hold five layers of balloon fabric together. Each 27 ft (8.2 m) balloon will carry 66 lb (30 kg) of instruments, probably UV spectroscope to measure chemical composition in the atmosphere; others to determine vertical and horizontal winds that churn the clouds. Each Venera orbiter will carry about 170 lb (77 kg) of equipment related to balloon experiment.

BIS DEVELOPMENT PROGRAMME

FUND RAISING: NEW BIS T-SHIRTS

To support its Development Appeal, the Society now has for sale a most attractive white, short-sleeve T-shirt, with the Society's emblem printed in dark blue on the front. Three sizes are available: small, medium and large. The price per shirt is £2.50 ($5.00) post-paid.

If this new venture proves successful, the Council plans to widen the range by providing other colours and designs.

As from **1 May 1979** orders should be sent to our new Offices at 27/29 South Lambeth Road, London, SW8 1SZ.

4 Details of Soviet and Chinese ballistic weapons deployments are given in U.S. Department of Defense annual report:

USSR

SS-16 This planned replacement for the solid-propellant SS-13 has been tested once only since 1975. "The Soviets have agreed as part of a SALT 2 treaty not to produce, test or deploy the SS-16 missile or certain of its components."

SS-17 Nearly 200 are in service. Being installed in SS-11 Sego silos modified for cold launch.

SS-18 Nearly 200 of these big ICBM's are now in service. Being installed in silos which originally held SS-9 Scarp at a rapid pace.

SS-19 Nearly 100 in service. Being installed in silos which originally held SS-11 Sego.

SS-20 Less than 100 operational, 50 per cent stationed in Western USSR.

China

CSS-3 "The People's Republic of China has developed a few multi-stage, limited-range, liquid-fuel ICBM's."

CSS-4 "A full-scale, liquid fuel ICBM continues under development. Full-range testing has not yet been attempted but the missile has been used successfully as a launcher of satellites."

7 Cosmos 1074 – suspected test vehicle for a manned or man-related spacecraft – is manoeuvred up to 364 x 384 km x 51.63 deg; period 91.96 min.

12 *Novosti* reveals that another Soviet Cosmos biosatellite for which U.S. experiments have been invited "will be launched late this year." According to Dr. Nikolai Gurovsky, head of Russian contributors, experiments will include study of mammals and birds in conditions of weightlessness. (See "Space Baby?" *Spaceflight*, February 1979, p. 72). Institute of Medical and Biological Research, Ministry of Health, is main participant but Moscow University and Timiryazev Institute of Plant Biology are also involved. Total of 15 joint experiments are planned most of them with rats but some with hen quails and plant tissue. U.S.-supplied dosimeters will provide data for improved methods of protecting space vehicles from space radiation. Previous spacecraft of this series were Cosmos 782 and Cosmos 956.

12 Soviets launch "a specialised oceanic satellite" Cosmos 1076 into orbit of 647-678 km x 82 deg; period 97 min. Objective: to provide quantitive evaluation of influence of ocean on Earth's weather; ice-reconnaissance, aid to sea navigation, and help for the fishing industry. Satellite is already sending data using "two telescopes trained on the ocean."

12 Burma opens ground station for communications *via* satellites, linking with 119 other countries in Intelsat network.

14 University of Surrey, Guildford, announces £150,000 plan to build small piggyback satellite for experiments by radio hams to learn more about Earth's ionosphere. Sponsors include British aerospace companies, Post Office, RAE, and Radio Society of Great Britain. Satellite to be launched as a secondary payload into a near-polar orbit by NASA in 1981.

14 *Novosti* reveals that new Bulgarian-made instruments for research into the ionosphere will be launched shortly on a Soviet satellite Auos.

14 Salyut 6 space station, launched 29 September 1977, "is still operating." Orbit ranges between 307-330 km x 51.6 deg to equator; period 90.7 min.

17 Last of four planned development firings of Thiokol Solid Rocket Boosters (SRB's) for Space Shuttle is successful at static test facility near Promentory, Utah. Three qualification firings are scheduled to begin this Spring.

19 Reported that NASA has re-submitted to Congress an application for the 25 kW solar power module to be included in the FY 1980 budget. Module would allow Shuttle Orbiter missions to be extended to three months. The space agency is looking towards the power module as a step towards a semi-permanent Solar-Terrestrial Observatory, including a free-flying Spacelab habitability module which could be left in orbit between Shuttle visits. (*The Power Module thus would make use of previously developed Spacelab hardware, including pallets and pointing systems as well as power distribution, data management and thermal control systems. NASA scientists are particularly interested in such a laboratory for the long-term study of the influence of solar emissions on the magnetosphere and the terrestrial environment in general. Ed.*).

22 U.S. National Research Council committee says it is "especially disturbed" by a NASA plan to hold certification test of the Space Shuttle Main Engine (SSME) using a powerplant which is not *exactly* the same as the flight model. Report was presented to a Senate Sub-Committee on Science, Technology and Space which has been holding hearings in Washington on the NASA Budget for FY 1980. If upheld the first launch of the Space Shuttle could be delayed a further five or six months. John Yardley, NASA Associate Administrator for Space Transportation Systems, said NASA had not thoroughly analysed the report.

20 JPL controllers alter trajectory of Voyager 1 by firing on-board engine for 205 seconds. Correction allows spacecraft to pass within some 280,000 km of Jupiter and 20,435 km of the moon Io.

25 Soviets launch Soyuz 32 from Tyuratam/Leninsk cosmodrome at 14 hrs 54 min (Moscow time). Cosmonauts are commander Lt-Col Vladimir Lyakhov, 37, and Flight Engineer Valery Ryumin, 39. Orbit ranges between 244 and 283 km x 51.6 deg; period 89.6 min.

[Continued on page 233

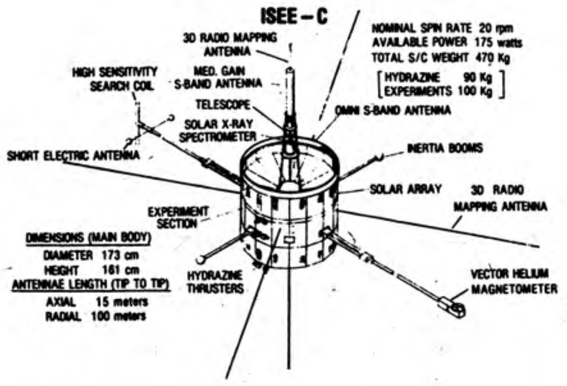
WE ARE MOVING.....

The Society will be moving to its new Headquarters building at 27/29 South Lambeth Road, London, SW8 1SZ as from **1 May 1979**.

Please note our new address from that date.

EARTH GETS A HALO

The First Libration Point Spacecraft



ISEE-C spacecraft.

National Aeronautics and Space Administration

Introduction

Although it may not deserve one, the Earth acquired a halo last November when a NASA satellite called International Sun-Earth Explorer 3 (ISEE 3) entered a giant "halo orbit" above the planet [1-15].

The reason for injecting the spacecraft into the halo orbit, the most unusual ever proposed for a NASA space mission, is to further man's understanding of solar-terrestrial relationships.

ISEE 3 was placed in orbit around the L-1 "Libration Point" that is located between the Earth and the Sun about 1.5 million km (or one million miles) from the Earth. The L-1 Libration Point is just one of several such points in the Earth's neighbourhood. At these points, the centrifugal and gravitational forces acting on a satellite are exactly counterbalanced. In its halo orbit around the L-1 Libration Point, ISEE 3 can monitor the characteristics of the solar wind and other solar-induced phenomena such as solar flares about an hour before they disturb the space environment near Earth.

The plan to place ISEE 3 in the halo orbit was devised by Dr. Robert W. Farquhar of the Goddard Space Flight Center Greenbelt, Maryland. According to Dr. Farquhar, "the orbit has been designed to pass slightly above and below the ecliptic plane so that it will avoid excessive solar interference with spacecraft communications back to Earth stations. To a person observing ISEE 3 from our planet, it appears to be orbiting the Sun, but it actually traces a halo above the Earth."

Upon entering the halo orbit a number of major space flight firsts were accomplished.

1. ISEE 3 became the first libration point satellite.

2. It was the first time a spacecraft had been stationed in a halo orbit.

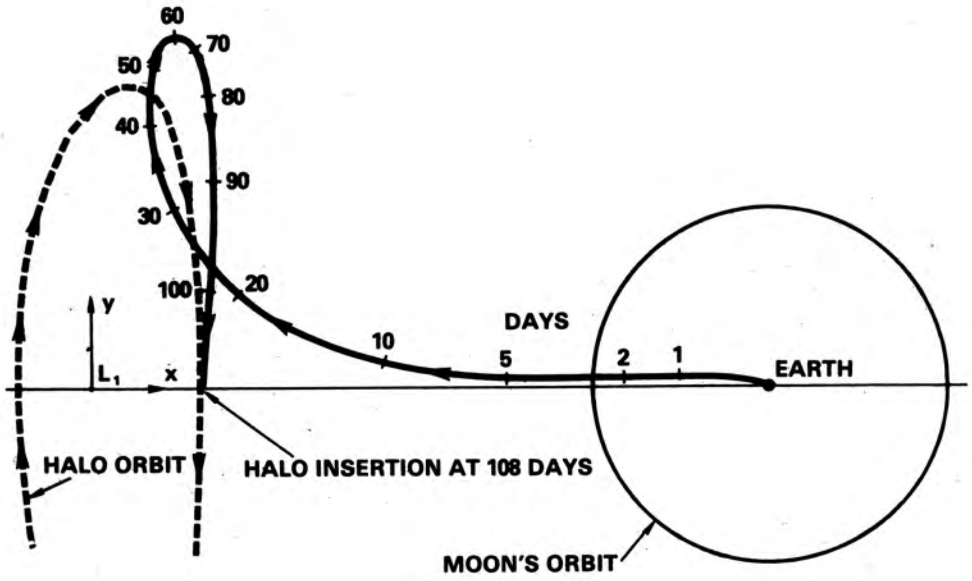
3. It was also the first time a spacecraft had orbited a point in space rather than a body such as the Sun, Earth or Moon,

Libration Points and Space Colonies

In recent years, there has been considerable interest in libration-point orbits because they are thought to be ideal locations for future space colonies. In addition, these orbits are advantageous for lunar farside communications and as staging locations for lunar and interplanetary transportation systems.

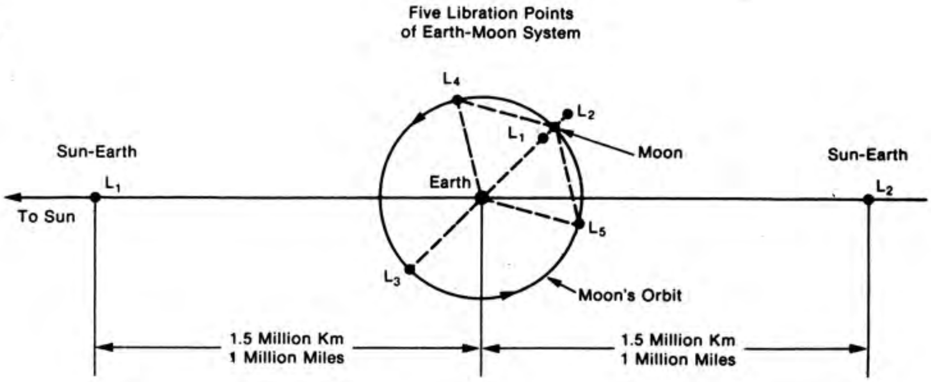
At least five of the libration points have been mentioned as possible sites for space colonies. But until now, research concerned with space colonisation has been mainly theoretical. ISEE 3 should provide the first real flight experience for orbital operations of future space colonies.

Now that ISEE 3 has been placed into the proper orbit, small stationkeeping manoeuvres will take place periodically. Approximately eight manoeuvres per year will be required of the spacecraft hydrazine system to maintain the satellite's proper position in space. ISEE 3 has enough hydrazine



Nominal transfer trajectory.

Seven libration points in the vicinity of Earth.



propellant to assure an orbital lifetime of at least ten years.

Project Manager Jeremiah J. Madden of the Goddard Space Center, who manages the ISEE 3 for NASA, explains that the unusual orbit was chosen for ISEE 3 "because of the relationship between ISEE 3 and the other two ISEE satellites launched from Cape Canaveral in October 1977."

Advance Warning Satellite

"In effect," says Madden, "ISEE 3 is an early warning satellite for activity on the Sun. It will detect solar wind particles speeding away from the Sun a full hour before the two other Earth-orbiting spacecraft do so. These spacecraft are in highly elliptical orbits ranging from about 280 km (174 miles) to almost 144,800 km (90,000 miles) above Earth. This tells scientists a lot about the Sun and how it changes with time and distance. In fact, this is the first time such correlated measurements have ever been accomplished on a regular basis."

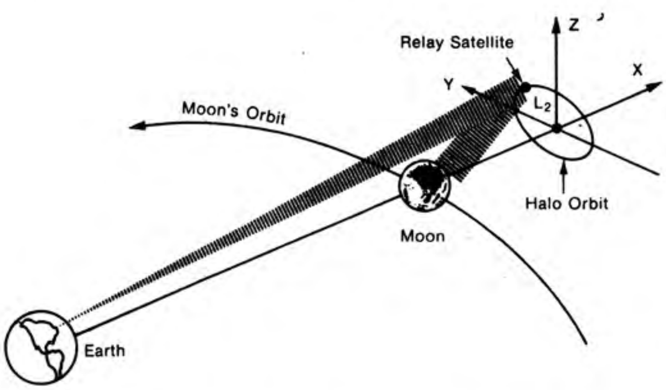
In addition to providing a far-out Sun-Earth measuring platform, ISEE 3 is also proving valuable for research activities on the origin of galactic cosmic rays and recently discovered gamma ray bursts.

Triple Spacecraft Mission

All three spacecraft will be closely observing phenomena at the period of maximum solar activity for the new 11-year cycle which began in June, 1976.

The three-spacecraft mission involves 117 scientific investigators from 35 universities and 10 nations. ISEE 3 carries 13 different scientific instruments, three of them by foreign investigators in Holland, Germany and France.

ISEE 1, managed by Goddard, and ISEE 2, managed by the European Space Agency, were the first set of spacecraft designed to be used together to investigate Earth's immediate space environment.



Lunar Far-Side communications with Halo Satellite.

The use of three spacecraft, separated by a controllable, variable distance, allows scientists to study the boundaries between interplanetary space and the space controlled by the Earth, and the nature of fluctuations in the boundaries.

ISEE coordination is designed to fit into the International Magnetospheric Study (IMS) programme, a world-wide three-year investigation begun in 1976.

As part of this programme, ground stations, sounding rockets, balloons, aircraft and satellites, including the ISEE spacecraft, will look at the same phenomenon simultaneously from different parts of the Earth, including polar areas and space. Data exchange offices have been established in Meudon France, and Boulder, Colorado.

Meanwhile, an advanced Satellite Situation Center (SSC) at Goddard calculates satellite orbits which are published through the Boulder office. The published SSC orbits are designed for correlation with the various IMS systems to indicate when spacecraft data are likely to be especially fruitful.

The coordinated effort is expected to result in a better understanding of how the Sun controls the Earth's fluctuating near-space environment and of a variety of solar-terrestrial phenomena, including weather and climate, energy production and ozone depletion in the atmosphere.

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[Concluded on page 240

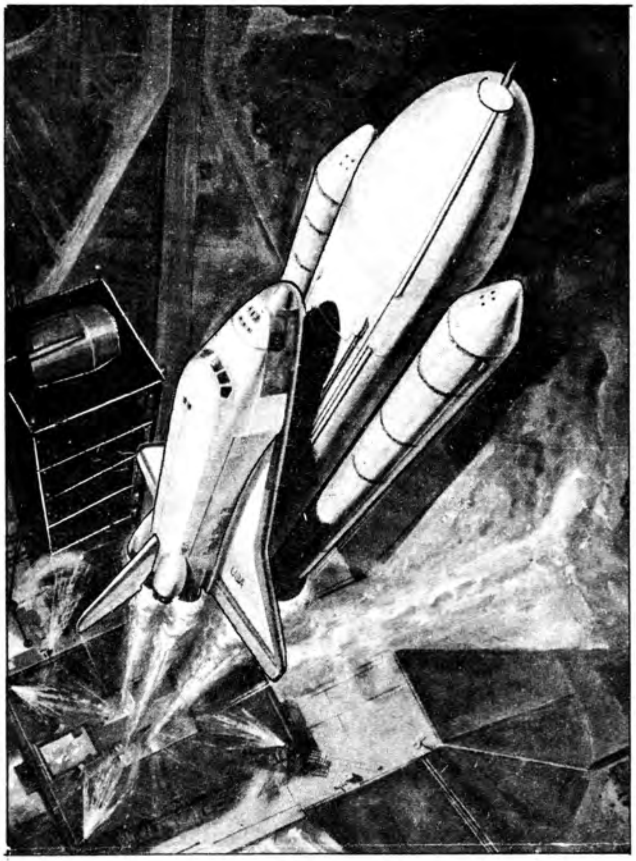
GETAWAY SPECIALS

THE NASA SMALL SELF-CONTAINED PAYLOAD PROGRAMME

By Chester M. Lee*

An imaginative offer has been made by the National Aeronautics and Space Administration to fly small experimental payloads in the Space Shuttle at low cost. The scheme is open to a wide range of participants and is not restricted to U.S. nationals. Types of users reserving space include private citizens, brokers, high schools, universities, non-profit organisations, foreign governments, professional societies and private industry. This article explains the procedure.

We shall be interested to hear from any individual or group willing to sponsor a research package. Proposals for exneriments from universities and similar departments able to set these up from within their own resources will also be most welcome. Some typical research areas include: Space processing – metals and plastics; communication; memory storage devices; biology (blood, lizard tail regrowth, bone decalcification in rats, and solar X-rays. – K.W.G.



Space Shuttle begins an exciting new era of space exploration. Besides major payloads, it will carry the hopes and ambitions of a number of 'small' researchers around the world.

Rockwell International

Introduction

In late 1980, the Space Shuttle will have completed its half-dozen developmental flights and will be into routine operations. On each flight, there will be one or more "primary payloads" in the Shuttle's payload bay. However, such payloads will not always occupy the total space available, or add up to the maximum allowable weight.

Strictly speaking, the Space Shuttle comprises the Orbiter vehicle together with the propulsion elements that thrust it into orbit. But routine space transportation in the 1980's will require more than the Shuttle; it will also need trained and proficient personnel, facilities, and support equipment. The combination of these is called the Space Transportation System.

As a matter of National policy, STS Operations must charge fees which cover the costs to operate the System.

The STS Operations Directorate at NASA Headquarters in Washington, D.C., which has broad responsibility for systems operations, is also responsible for establishing and conducting a programme to fly small experiments that will take advantage of the extra space/weight opportunities as they arise. This constitutes an unusual opportunity for individuals, commercial firms and educational institutions that would like to conduct experiments in space at a moderate cost. The name of the programme is the Small Self-Contained Payload or "Getaway Special."

This programme is still being formulated; many criteria and methods/procedures are still to be defined. However, a number of potential experimenters have expressed serious interest in the programme and NASA has already accepted earnest money payments to fly a large number of experiments. The purpose of this article is to inform prospective experimenters the status of the programme, present trends, and the likely time scale for further developments.

Basic Rules and Criteria

The cornerstone of the SSCP Program is paragraph 4d of NASA Management Instruction 8610.8 (see Appendix 1). Its provisions and certain interpretations/extensions are set forth in this article.

Who can participate? Any responsible person, organisation or educational institution can take advantage of this programme. U.S. citizenship is not required, but the person or entity must be able to enter into a contract with NASA under which each party will undertake certain responsibilities and payment will be made.

What do we fly? A "small self-contained research and development payload." For practical reasons, the payload must be a package that has:

- Mounting lugs or surfaces to attach to the experiment mounting plate NASA will furnish.
- A form which will fit into the NASA provided cylindrical container.
- Weight not to exceed 200 lb (90.7 kg).
- Volume not more than 5 ft^3 (0.141 m^3).

What about lesser weight/volume? We find that volume is more useful than weight for coordination and control, particularly in the early stages of the programme. The minimum volume will be 1.5 ft^3 (0.042 m^3), the corresponding minimum charge is $3,000. Another discrete volume has been set at 2.5 ft^3 (0.0708 m^3), with a cost of $5,000. The maximum volume is 5.0 ft^3 (0.141 m^3), with a cost of $10,000. Corresponding weight limits are 60, 100 and 200 lb (27.2, 45.3 and 90.7 kg), respectively.

* *Director, Special Transportation System (STS) Operations, National Aeronautics and Space Administration, Washington, D.C., U.S.A.*

These prices are in Fiscal Year 1975 dollars. The 1975 dollar price will be adjusted to reflect escalation to the date each payment is due. The escalation adjustment will be based on the Bureau of Labor Statistics "Compensation Per Hour Index" for the private business sector.

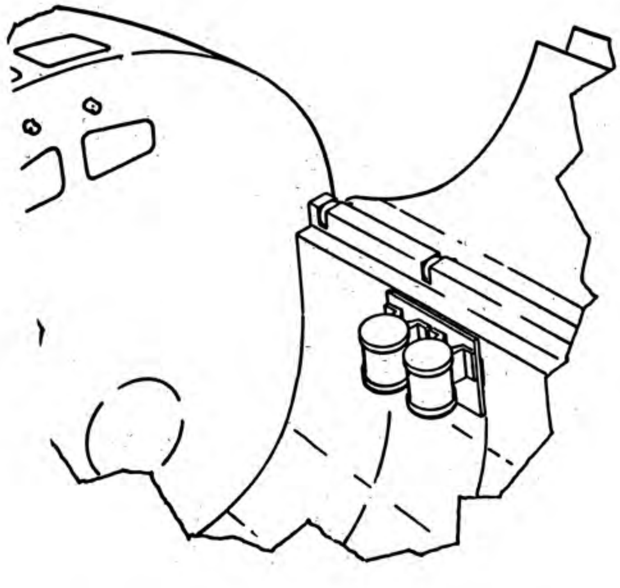
As an example, if your flight was scheduled to fly in June 1978, the inflation rate would be approximately 33%. Therefore, the total cost for a $10,000 payload would be $13,300 in FY 1978 dollars.

Research and Development Restriction – Small self-contained payloads shall be used only to conduct experiments of a scientific research and development nature. NASA will not attempt to judge the scientific merit or novelty of a proposed experiment, or even whether it will work as intended, but all users will be required to furnish NASA with sufficient information to verify peaceful purposes and NASA's and the U.S. Government's continued compliance with law and the Government's obligations. Experiments to develop and refine proprietary processes are acceptable and in fact encouraged. NASA will not collaborate in the formulation of any experiments or the interpretation of their results. However, NASA shall reserve the right to reject any payload which, in the opinion of the NASA Administrator, would be contrary to the spirit of this programme or NASA's mission.

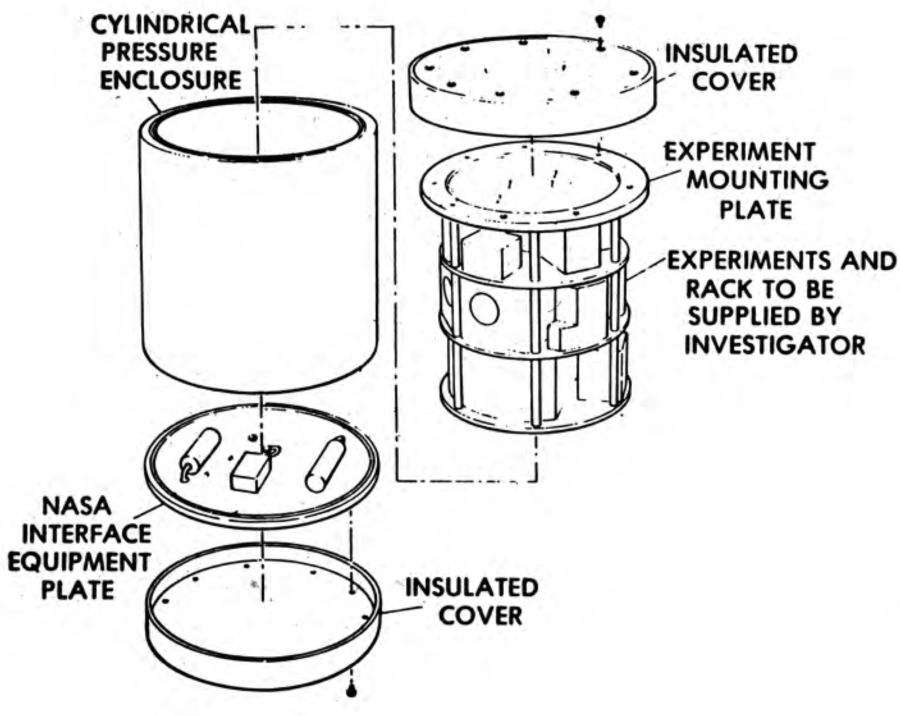
Can the package be subdivided? It is necessary that a single individual or entity remains answerable to NASA for the R&D nature and furnish NASA with sufficient information to insure Shuttle safety of the total package, for its timely availability to be flown, final payment, and other obligations under the contract. Within these constraints, it is acceptable for the participant to subdivide the package into more than one experiment. Any difficulties relative to sub-experimenters must be resolved by the prime participant without NASA involvement.

Transfer of Ownership – Prior to the signing of a launch services agreement, users will be permitted to transfer ownership of their payload to another party provided NASA is informed of the transfer. There will be no change in the flight priority number as a result of the change in ownership. After the signing of the launch agreement, transfer of ownership is only permitted by NASA written approval.

Safety – Any mishap could jeopardise the Orbiter's recovery with possible loss of life and destruction of invaluable resources. Numerous painstaking safety precautions are being applied to the design and testing of all flight hardware, as well as to the operating procedures. An effort will be made to simplify and streamline these requirements as they apply to the Getaway Special experiments, but experimenters are cautioned that there are a certain minimum set

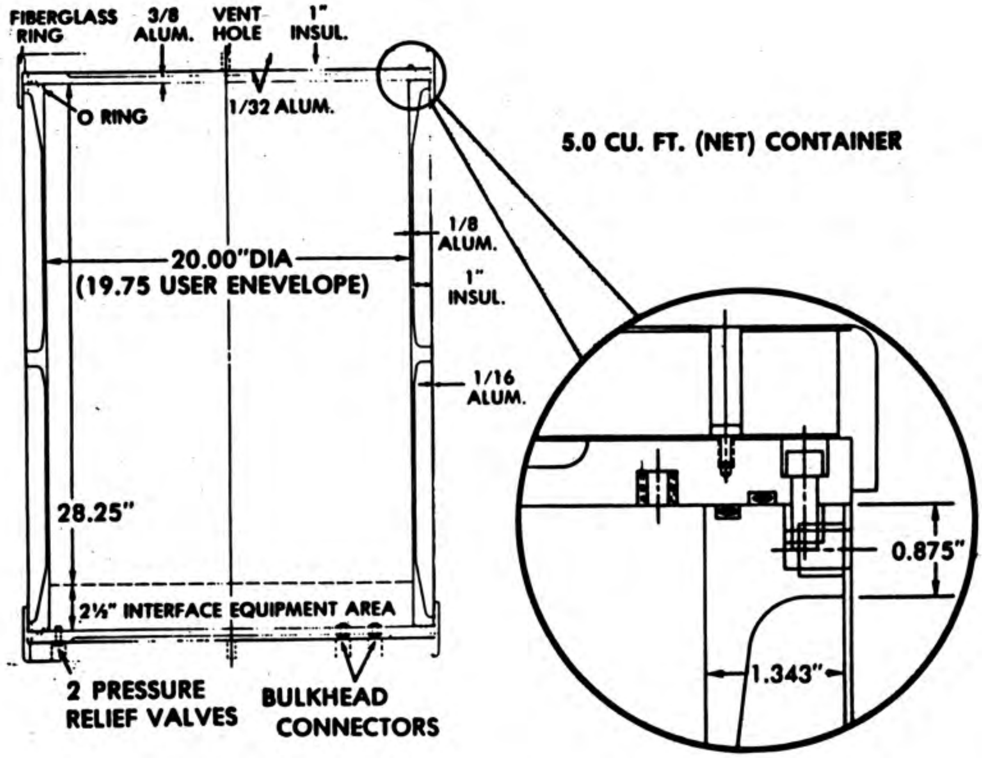


Getaway Special – small self-contained payloads (GSFC Sounding Rocket Project).



Small self-contained payloads – Container Concept.

Small self-contained payloads – container dimensions.



of requirements that NASA must invoke. NASA shall reserve the right to inspect and/or test any and all materials, components, and elements of the payload at any time.

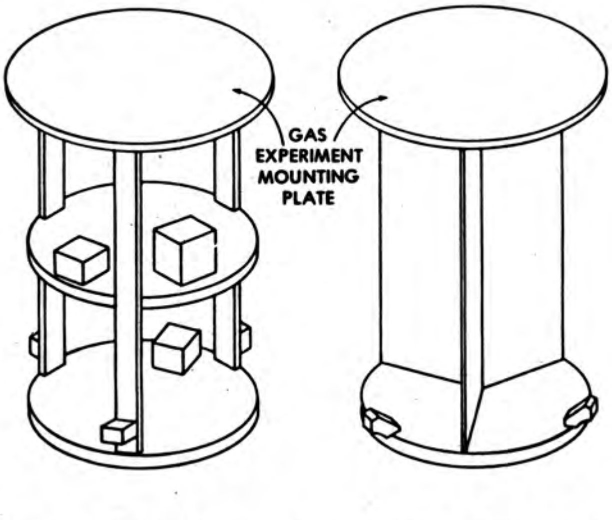
Humane restrictions – Experiments using animal subjects shall be performed in a humane manner in accordance with the U.S. Department of Health, Education and Welfare Publication No. (NIH) 74-23 "Guide for the Care and Use of Laboratory Animals."

Priority/Sequence – In general, experiments will be flown on a first come, first served, space-available basis. There are other considerations, some of which will be determined by the specific needs of the experimenters (mission duration, inclination, etc.) that may necessitate schedule arrangement. Delays in satisfying NASA's requirements, particularly concerning safety, could also cause rescheduling.

Payments – For this programme, the deposit for "earnest money" is $500, regardless of payload size. The remaining basic payment schedule, including an incremental payment of 50% of the total price of the payload at the time the launch agreement is signed, is under review by NASA management and will be issued when approved by the NASA Administrator.

Does NASA guarantee flight according to the schedule? No, because a key aspect of the programme is to fly these payloads on a space-available basis. Unexpected contingencies could force rescheduling of your mission. However, NASA will provide another flight opportunity at no additional charge in the event it fails to fulfill its obligations under the launch agreement or in the event NASA-supplied hardware fails to work properly.

NASA liability – NASA assumes no liability in connection with flight of an experiment, except as stated above.



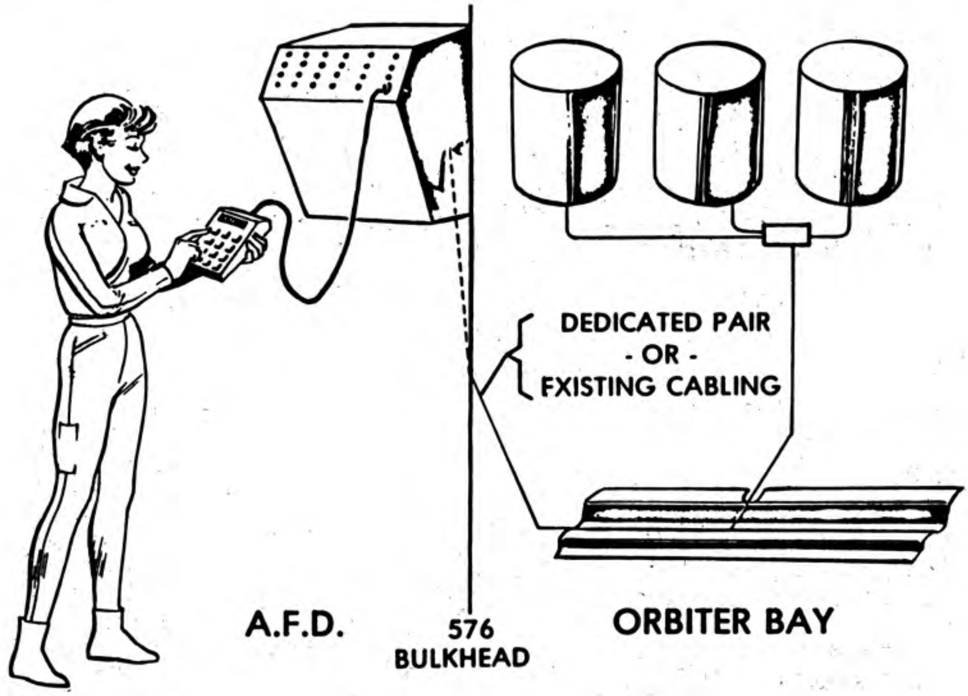
Small self-contained payloads. Suggested payload packaging techniques.

How NASA is Preparing

As already noted, this programme is still in its formative stages; however, we are currently in the process of formalising the Small Self-Contained Payload Policy, which will be an addendum to our NASA Management Instruction 8610.8. We want to adapt to the emerging needs of the experimenters, within the constraints of cost, safety, and other realities.

The Goddard Space Flight Center (GSFC) Sounding Rocket Division will act as the technical interface with the users of these payloads and will advise you in any technical aspects throughout the development of your payload and can be consulted on any unresolved issues noted in this article.

NASA's Kennedy Space Center (KSC) in Florida will assemble and launch all Shuttle vehicles until about 1983. Thereafter, launches will also take place from Vandenberg Air Force Base (VAFB) in California, with KSC collabora-



Small self-contained payloads. Control concept.

tion. Therefore, KSC is an important participant in preparation for your flight and handling of your experiment. Similarly, the Johnson Space Center in Houston is responsible for integration of the total mission and for planning of crew activities. So they too have a vital role.

The GSFC will serve as the primary NASA interface to schedule your flight date with JSC and KSC.

What is Supplied

What does NASA supply under this programme?

Flight and return – The main objective, of course, is to carry your experiment in the Orbiter's cargo bay for a flight in low-Earth orbit, and then return it to you. More about the flight can be obtained from Appendix 2.

Information – In support of this objective, we will supply you planning and technical information in greater breadth and depth than is possible in this article. The GSFC will develop and issue generic information as the programme progresses.

Hardware – NASA will provide the cylindrical container in which your payload will be carried on the Shuttle. The planned characteristics of these standard containers are presented in Appendix 3.

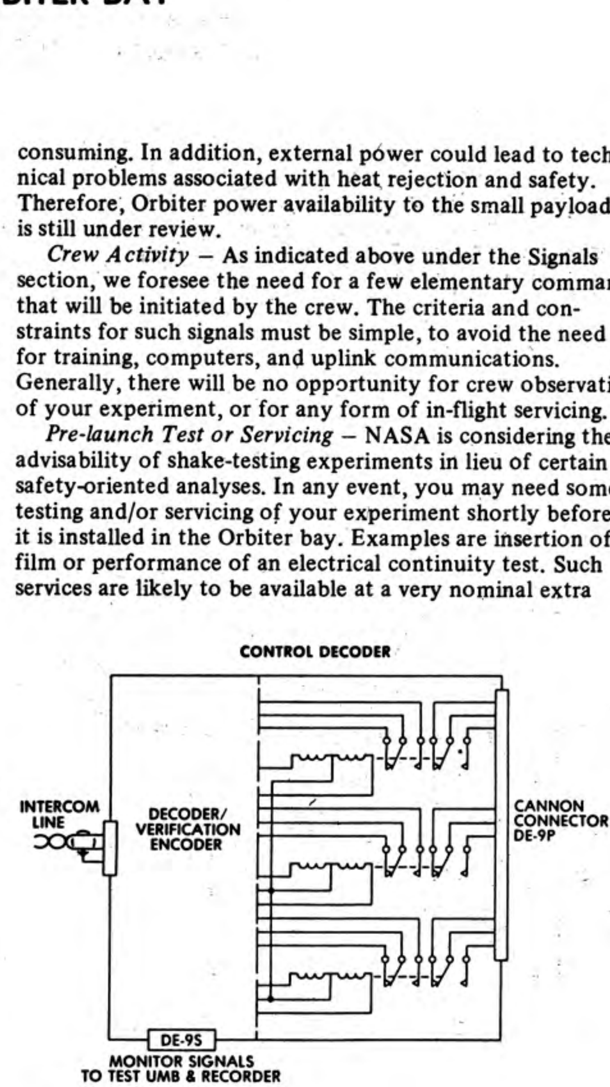
We are considering the supply of certain optional hardware, but the final decision on this depends on the extent to which the various items are likely to be used. Most, if not all, of these items will entail extra charge; we are searching for ways to serve the need at a modest cost. GSFC will be able to advise you on space-qualified components such as timers, recorders, sequencers, and batteries.

Signals – We are exploring means to supply three on-off control signals from the crew station. Such controls will take the form of latching relays capable of switching low amperage 28 VDC.

Power – It is recognised that most experimenters would like electrical power supplied from the Orbiter to provide thermal conditioning if for no other reason. On the other hand, the Orbiter fuel cells (batteries) will face heavy demands from the primary payloads and routine operations. To add fuel cells to the Orbiter is both expensive and time-consuming. In addition, external power could lead to technical problems associated with heat rejection and safety. Therefore, Orbiter power availability to the small payloads is still under review.

Crew Activity – As indicated above under the Signals section, we foresee the need for a few elementary commands that will be initiated by the crew. The criteria and constraints for such signals must be simple, to avoid the need for training, computers, and uplink communications. Generally, there will be no opportunity for crew observation of your experiment, or for any form of in-flight servicing.

Pre-launch Test or Servicing – NASA is considering the advisability of shake-testing experiments in lieu of certain safety-oriented analyses. In any event, you may need some testing and/or servicing of your experiment shortly before it is installed in the Orbiter bay. Examples are insertion of film or performance of an electrical continuity test. Such services are likely to be available at a very nominal extra



Small self-contained payloads.

charge. Insertion of specimens after the package has been installed in the Orbiter may be provided as a chargeable option.

Post-flight Information – NASA will issue a certificate attesting to the fact that your experiment was orbited on a particular Space Shuttle flight and the associated date(s). In addition, we will furnish a brief summary of the timing and orbital parameters, so that you can determine the conditions prevailing when your experiment was active. More comprehensive after-the-fact computer data on the particular orbit may be available at some additional charge.

What You Need to Do

The first thing NASA needs from you is the payment of $500 earnest money as a confirmation of serious intentions to cover our expenses for initial coordination, planning, and launch agreement negotiations.

Then we will need information on your needs and desires with respect to such matters as:

- Orbit altitude, inclination, duration.
- Orbiter attitude, when experiment is activated.
- Optional experiment support hardware or services.
- Signals.
- Pre-launch tests or servicing.

As noted earlier, we must also ask for certain specifics to confirm the R&D nature of the experiment.

Within eighteen months after receipt of the earnest money, a Launch Agreement should be signed. (The exact content of this Agreement is still being established.) This will be the binding document that legally defines the obligations of both parties thereafter. One should understand that the contents of this article and other impressions one may gain from discussions or even correspondence with NASA personnel do not constitute formal commitments. Normally, dialogue will continue to finalise the list of optional services (if any) you will want, and NASA will define the charges for such services. Discussions will also be held to understand and resolve technical problems.

Approximately one year before a planned Shuttle launch, NASA will estimate the number of available spaces for SSCP's, make tentative flight assignments, and establish dates for payload delivery to the launch site.

During the final year, we will need input data to support a safety certification and to permit a final technical/thermodynamic check. This is necessary because the temperature of your package (or at least the power needed to maintain a given temperature) is sensitive to the duration in various attitudes relative to the Sun, as well as the anticipated temperature of the remaining cargo.

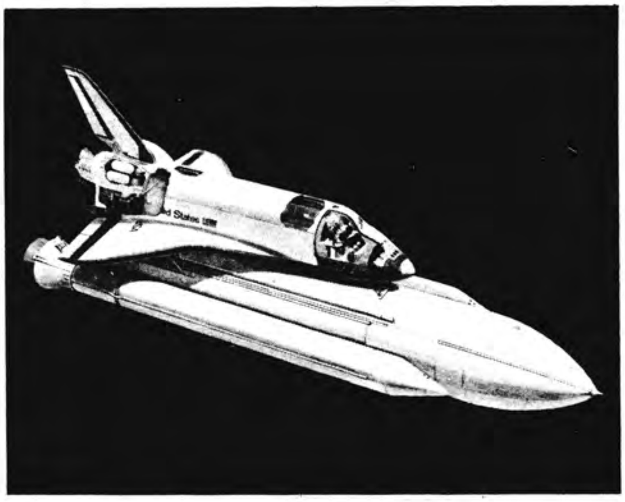
Roughly two months before the scheduled flight, the package must be delivered to NASA. Many similar experiments have been sent successfully by commercial means, but you may choose to deliver it in person. The point of acceptance will normally be the launch site, KSC.

We will need to work together to arrive at a post-flight plan which will cover:

- How the experiment will be returned to you.
- How any NASA-owned reusable hardware will be returned.
- Need for supplementary flight data.

How to Proceed

The key individual in the STS Office to answer any inquiries you may have is Donna Skidmore. Her phone number is 202-755-2427.



Space Shuttle – a galaxy of payloads, from the ESA Spacelab to 'getaway specials'.

Rockwell International

When you are ready to go ahead, we need your cheque for $500 payable to NASA. It should be mailed to the Director of Financial Management, Code BF-6, with a letter stating that it is earnest money for a flight in the Getaway Special Programme. A copy of the letter should be sent to Chester M. Lee, Director, Space Transportation Systems Operations, Code MO-6. Both are at NASA Headquarters, Washington, D.C. 20546 (no street address is needed).

You will receive an acknowledgement in approximately 10 days. Then we will be working together to make your space experiment a reality!

APPENDIX 1: NMI 8610.8 21 January 1977

Small Self-Contained Payloads. Packages under 200 lb (90.7 kg) and smaller than five cubic feet which require no Shuttle services (power, deployment, etc.), and are for R&D purposes, will be flown on a space-available basis during both phases of Shuttle operation. The price for this service will be negotiated based on size and weight, but will not exceed $10,000 in 1975 dollars. A minimum charge of $3,000 in 1975 dollars will be made. If Shuttle services are required, the price will be individually negotiated. Reimbursement to NASA will be made at the time the package is scheduled for flight.

APPENDIX 2: Shuttle Parameters

The following are estimated characteristics for KSC Shuttle flights applicable to this programme. After 1982, some flights will be from VAFB with near-polar inclinations and other variations.

Other facts are available in the booklet "Space Shuttle", GPO Stock Number 033-00-00651-9, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price – $3.40.

Pre-launch, the cargo bay atmosphere is filtered air or nitrogen at 20°C (70°F) and less than 50% R.H. The cargo bay doors will be opened between one and four hours after lift-off and remain open throughout the orbital part of the mission.

Entry and Landing

The cargo bay doors are closed between one and four hours before landing. During de-orbit and entry, accelerations/vibrations/temperatures are within the values described

ORBITAL PARAMETERS	Maximum	Minimum	Typical
Duration	30 days	1 day	3-4 days
Inclination	56°	28-1/2°	30-35°
Altitude	>750 km	200 km	250-300 km
Period (minutes)	>100 min	89 min	90 min
% of time in Earth shadow	40%	32%	36-38°
Temperature of nearby structure	90°C (200°F)	-160°C (-250°F)	+60 to -50°C (+150 to -50°F)
Steady-state acceleration	10^{-4} g	10^{-7} g	10^{-5} g
Acceleration in manoeuvres	.04 g	–	TBD
Pressure	10^{-9} atm	10^{-4} atm	10^{-10} atm

Some flights will have the payload bay generally oriented toward the Earth; some, away from the Earth; some, a mixture.

ASCENT	Maximum	Typical
Duration of powered flight	12 min	8 min
Longitudinal acceleration	3.7 g	3 g
Transverse acceleration	3.9 g	1-2 g
Angular acceleration	3 rad/sec^2	1 rad/sec^2
Noise	145 db 5-10 seconds	130 db
Vibration	.1 g^2/Hz 20 seconds	.04 g^2/Hz
Temperature of nearby structure	60°C-150°F	30°C (85°F)

above for ascent except that the longitudinal accelerations range between 0 and 1.1 g forward.

At touchdown, design accelerations are:

4.2 g vertical
1.8 g forward — These include dynamic transient effects and may occur simultaneously.
1.2 g lateral

During a 15 minute period after touchdown, temperature of the nearby structure rises to the order of 80°C (180°F). It drops to ambient within another half-hour. During this time, there is forced air circulation at approximately ambient temperature.

APPENDIX 3: Containers

The NASA will provide a standard container in which your payload must fly. The container weight and volume are not counted against your allowed payload weight and volume. Also, it is part of the standard services provided for the basic charge. The form of the container is shown in the figure.

Size

There will be two container sizes. One will carry a 5 ft^3 (0.141 m^3) payload. The other will house either a 2.5 (0.078) or a 1.5 ft^3 (0.0425 m^3) payload. The internal dimensions on all containers will provide for a payload 19.75 in (50.16 cm) in diameter. The length of the container will vary depending on the payload volume. For example, the 5 ft^3 (0.141 m^3) container will have a payload envelope 28.2 in (72.7 cm) long.

Orientation

The containers will be mounted with the experiment mounting plate facing out of the Orbiter payload bay. Thus, the cylinder axis will be roughly vertical when the Orbiter is setting on its landing gear and horizontal when the Orbiter is on the Pad ready for launch.

Thermal Characteristics

The container will be insulated on the sides and bottom to make it easier for you to control the internal temperature. The top (experiment mounting plate) will be the primary surface for the radiation or absorption of heat. Its covering can be varied to suit your payload and mission.

Venting

The container can fly sealed to maintain about one atmosphere internal pressure. Alternatively, it can be vented to allow it to reach the space vacuum. If venting is desired, you must exercise more care in the selection of experiment materials to avoid outgassing which may contaminate your own and other experiments. To minimise your contamination effects on other experiments and, therefore, the need for large amounts of materials documentation, the container can be evacuated prior to flight and kept sealed.

Opening or Window

Consideration is being given to a lid in the top of the container which can be opened and closed on command from the crew station. Here again this requires more careful consideration of experiment materials because of the potential for contamination of other payloads. Alternatively, there may be a window as large as 8 in (20.3 cm) diameter that will have good transparency throughout the visible spectrum and extend into the ultra-violet range. Both of these special top plates, if available, will be optional hardware provided at additional cost to the user.

Interface Area

At the bottom of every container will be a 3 in (7.6 cm) high space for NASA interface equipment such as the control signal relays and vents.

Internal Mounting

Your payload will mount to the experiment mounting plate using a standard bolt hole pattern provided in that plate. The payload will be inserted into the container after mounting to the plate. Snubbers (soft bumpers) at the bottom of the payload structure that can be screwed out against the side of the container are required to inhibit payload vibration inside the container.

Usage

The containers will be kept by NASA at all times. Installation of the payload onto the mounting plate and into the container will take place at a NASA facility (normally the Kennedy Space Center). NASA will provide shipping containers which will have the same payload envelope as the flight containers. Also, shipping mounting plates will have a bolt hole pattern identical to the flight experiment mounting plate.

Mr. Neville Kidger wishes to thank the BBC Monitoring Service for translations of material used by him in recent Space Report items on the Salyut programme, including " 'Photons' over the Earth" (Spaceflight, January 1979, pp. 34-36); "Soyuz 31 Redocks with Salyut 6" (Spaceflight, February 1979, pp. 72-74) and extracts from the Moscow Press Conference by cosmonauts Kovalenok and Ivanchenkov on pages 212-214 of the present issue.

GERMANY STUDIES DIRECT-TV SATELLITE

A detailed proposal has been submitted to the German Federal Ministry of Research and Technology for a television satellite (TV-SAT) for the Federal Republic of Germany which could transmit three television programmes directly into every home from a geostationary orbit, starting in 1983. All that would be needed on the ground would be a parabolic antenna only 70 to 90 cm in size and a frequency converter.

Definition of the TV-SAT was undertaken under a DM 6 million study contract from the Federal Ministry by the Messerschmitt-Bölkow-Blohm Space Division, with the co-operation of AEG-Telefunken, Dornier System, ERNO Raumfahrttechnik and SEL.

To provide direct transmission of television programmes *via* satellite a new generation of satellites is needed, with a mass of approximately 1,000 kg (2,204 lb) and an electric power of 3 kW. The transmitter power required in orbit is 235 watts per channel, compared with the 5 to 20 watts needed in conventional communications satellites.

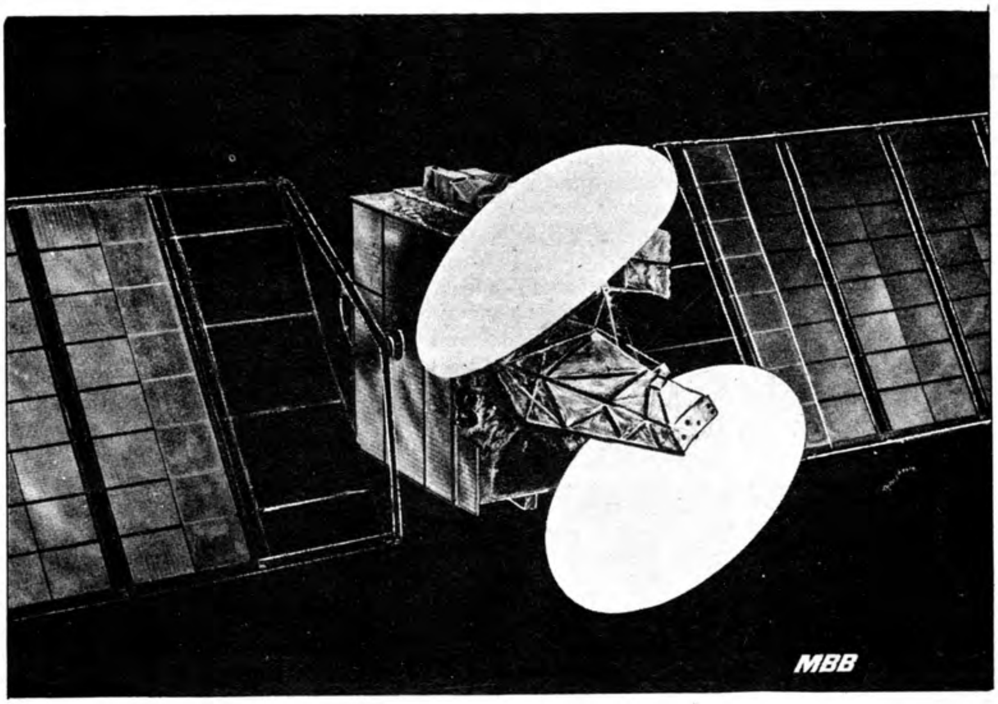
Both the life of such satellites and their operating reliability must be as high as possible, for economic reasons. For this purpose, the Satellite Bus has been designed for a life of 10 years in orbit, which has been obtained by means of three-fold redundancy for critical electronic components and by using electric thrust units for orbit control.

The satellite itself is of up-to-date modular design, using the combined bi-propellant propulsion system now under development at MBB for the U.S. Jupiter Orbiter "Galileo".

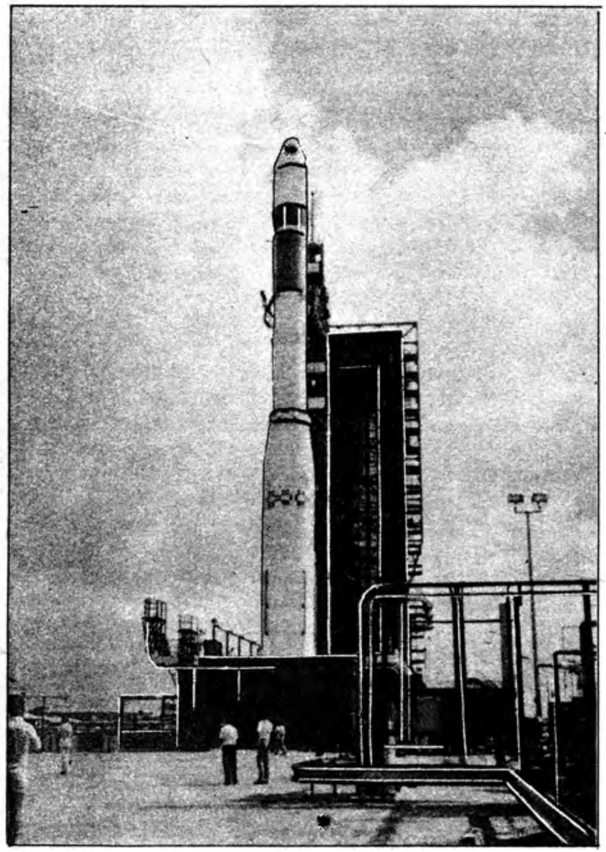
The Federal Postal Administration and the broadcasting corporations are taking an active part in preparations for satellite television transmission in the Federal Republic. Pre-operational transmissions could begin in 1983 and full-scale operations, with facilities for five television channels in 1986. However, at least one TV channel will be used for 16 sound radio programmes and two more for the existing two main German TV programmes (ARD and ZDF), so that only two new programme channels will remain.

Distinguished visitors from the People's Republic of China came to the Marshall Space Flight Center in Huntsville, Alabama, last January. Here Eugene H. Cagle (right), director of the Marshall Center's Test Laboratory, explains Shuttle components to Dr. Jen Hsin-min (centre), director of the Chinese Academy of Space Technology.

NASA Marshall Space Flight Center

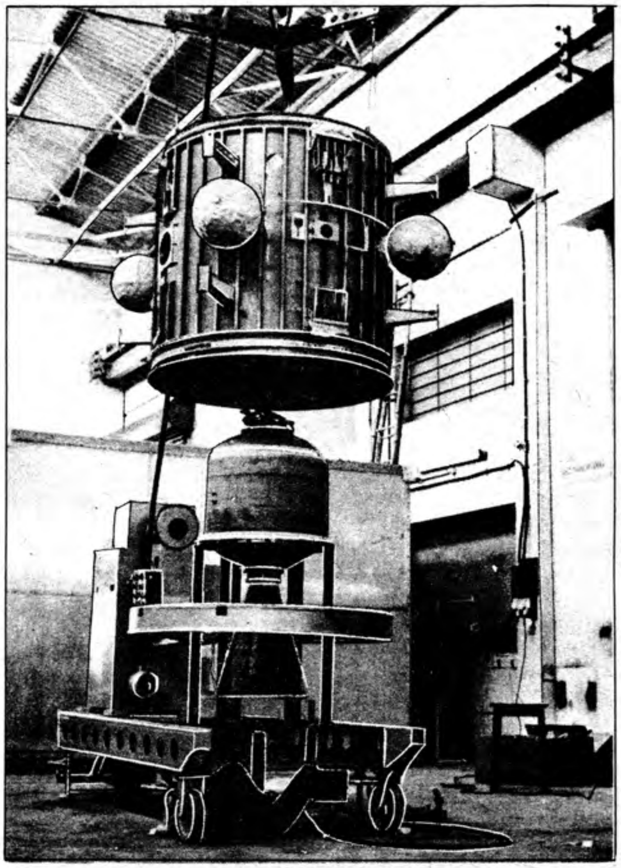


TELEVISION SATELLITE proposed by Messerschmitt-Bölkow-Blohm, showing box-like centre body, directional antennae and rotatable solar cell 'wings'.



Engineering model of ESA Ariane launch vehicle on the pad at the Guiana Space Centre, Kourou. First development launch – of Ariane L01 – is scheduled for early November 1979.

Theo Pirard



Apple thermal model being integrated with apogee rocket.

Indian Space Research Organisation

SETI AT AGE 10

The Soviet press writes in glowing terms of a ten-year-old schoolboy, Nikita Balashov, whose great ambition is to become an astrophysicist "studying the possible existence of extra-terrestrial civilisations."

Nikita caused something of a stir at Moscow's Youth Week of Science, Technology and Production by presenting a paper "Describing Oscillating Motions in the Solid Body of Quasi-Particles."

In it he summed up the present position in the field and added some serious views of his own.

Nikita is already in the 6th form at school – normally occupied by 12-13 year olds – and expects to reach the eighth or ninth by the end of the year. Although his main passion is physics, he is well read in classical literature and plays both violin and piano.

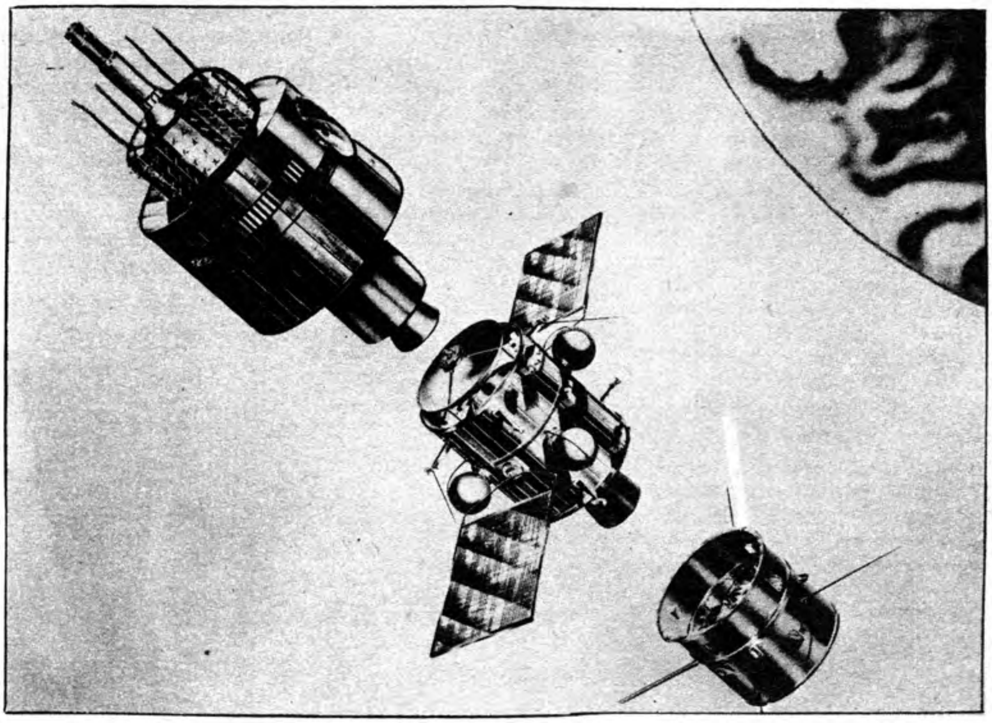
INDIA'S 'APPLE' SATELLITE

When in 1977, the European Space Agency offered free space on the four Ariane development flights, ISRO jumped at the offer and got space on the third flight, despite having no previous experience in developing such a complex satellite on an extremely tight schedule. Fabrication of the first Indian experimental communications satellite, known as Ariane Passenger Payload Experiment (APPLE), began in January 1978, and the first unit was completed last September for thermal tests at Toulouse. The second frame, delivered on 8 October 1978, was for structural tests at the National Aeronautical Laboratory, Bangalore. Third is an engineering model with all equipment in place for balancing and other tests. The fourth and fifth are prototype and flight models. The latter will be handed over at Toulouse by December 1979, for launch in May 1980, along with the Meteosat and the CAT module (a CNES technology satellite).

APPLE is a 630 kg 3-axis stabilised geostationary communications satellite. Its cylindrical structure is 1.2 m in diameter, and 1.2 m high. Overall height, including the apogee kick motor, is 1.985 m, while the width across the deployed solar panels is 4.665 m.

The structure, of 24 ST aluminium alloy, is primarily rivetted. All packages are of magnesium alloy. Its two end and two centre rings were machined by Hindustan Aeronautics Ltd., Bangalore, from forged stock. HAL Nasik undertook honeycomb development and fabrication, based on experience with the MiG-21. APPLE's structure had to be stiffened as it has to bear the weight of the Meteosat above it. Several weight reduction techniques have been incorporated, e.g. milled ribs were used to save 3 kg weight. The magnesium castings were made at the Defence Metallurgical Research Laboratory, Hyderabad.

APPLE's communications payload consists of two C-band 4-6 GHz transponders (one redundant), with the TWTs/TWTAs by Hughes International. A 900 mm diameter fibreglass antenna, made at the Reinforced Plastics Group is mounted atop APPLE to transmit in 3,700 to 4,200 MHz and receive in 5,295 to 6,425 MHz bands. Peak radiated



Artist's impression of Meteosat 2, 'Apple' and Capsule Ariane Technologique (CAT) at the moment of injection into orbit.

European Space Agency

power is 31.5 dBW. The complete payload is being made at the Space Applications Centre of ISRO in Ahmedabad.

Electrical power will be supplied by two deployable Sun-pointing 1.2 m² solar arrays of 241 w total power. It has Hughes Spectolab cells and an array drive system by British Aerospace. Indian equivalents of both are under development. The 300 WH storage batteries are by SAFT. Attitude control and station-keeping will be by monopropellant hydrazine reaction control system by Hamilton Standard, and two momentum wheels (one redundant). Hydrazine capacity will limit APPLE's operational life to about 2 years.

The SLV-3 fourth-stage fibreglass solid-propellant motor is used as an apogee kick motor for APPLE.

ISRO's Space Applications Centre is developing a 3 kw, 150 MHz VHF transmitter for the ISRO Satellite Tracking Network (ISTRAC). It will be used for telecommand and ranging of APPLE in orbit, as well as during the launch phase. Its high power output has been achieved using Indian made vacuum tubes. After launch, APPLE will be stationed at 102°E longitude when its orbiting mass will be 352 kg. It will be the forerunner of India's multi-purpose, operational communications satellites of the 1990's. Total investment in APPLE is about R.s.150 million including salaries, equipment purchased, etc.

I visited ESA at the CNES establishment in Toulouse early last December. Dr. Ing. Dieter Lennertz, Head of ESA's Earth Observations Programme, stated that the first (L 01) experimental launch would be in July 1979, followed by L 02 in December that year. The third development round, to carry the APPLE satellite, would lift of in May 1980.

ESA has since announced that the test programme will be delayed. The timetable is LO1 – early November 1979; LO2 – early March 1980; LO3 – June 1980. Ed.

Apart from the APPLE, Ariane L 03 will also launch the CAT Module (Capsule Ariane Technologique) which is designed to check in-flight performance parameters like vibration, temperature levels, etc., which will then be transmitted to Earth.

Meteosat 2, the other satellite, has completed its thermal tests, and vibration tests at Ariane levels were being undertaken in early 1979, after modifications to its structure had been verified on the prototype and implemented on the F2 model.

Meteosat 1, launched on 23 November 1977, continues to perform impeccably. It transmits excellent images of the Earth every ½ hr. in the visible and two IR bands, and also retransmits to the primary and secondary data users stations some 300 formats per day in various digital or analogue forms. The first GARP (Global Atmospheric Research Programme) experiment began on 1 December 1978.

Meteosat 1 also acts as a relay for the dissemination of image data from the US GOES 2 satellite. The first image data transmission tests, from GOES 1, *via* Meteosat 1, began last November. Experiments have been successfully carried out with about 15 meteorological data collection platforms, with 10 more to be set up in 1979. Of particular importance is the immediately available meteorological data such as wind speed, cloud height, sea surface temperature, etc. A feature unique to Meteosat is the water vapour IR channel which no other satellite has had to date.

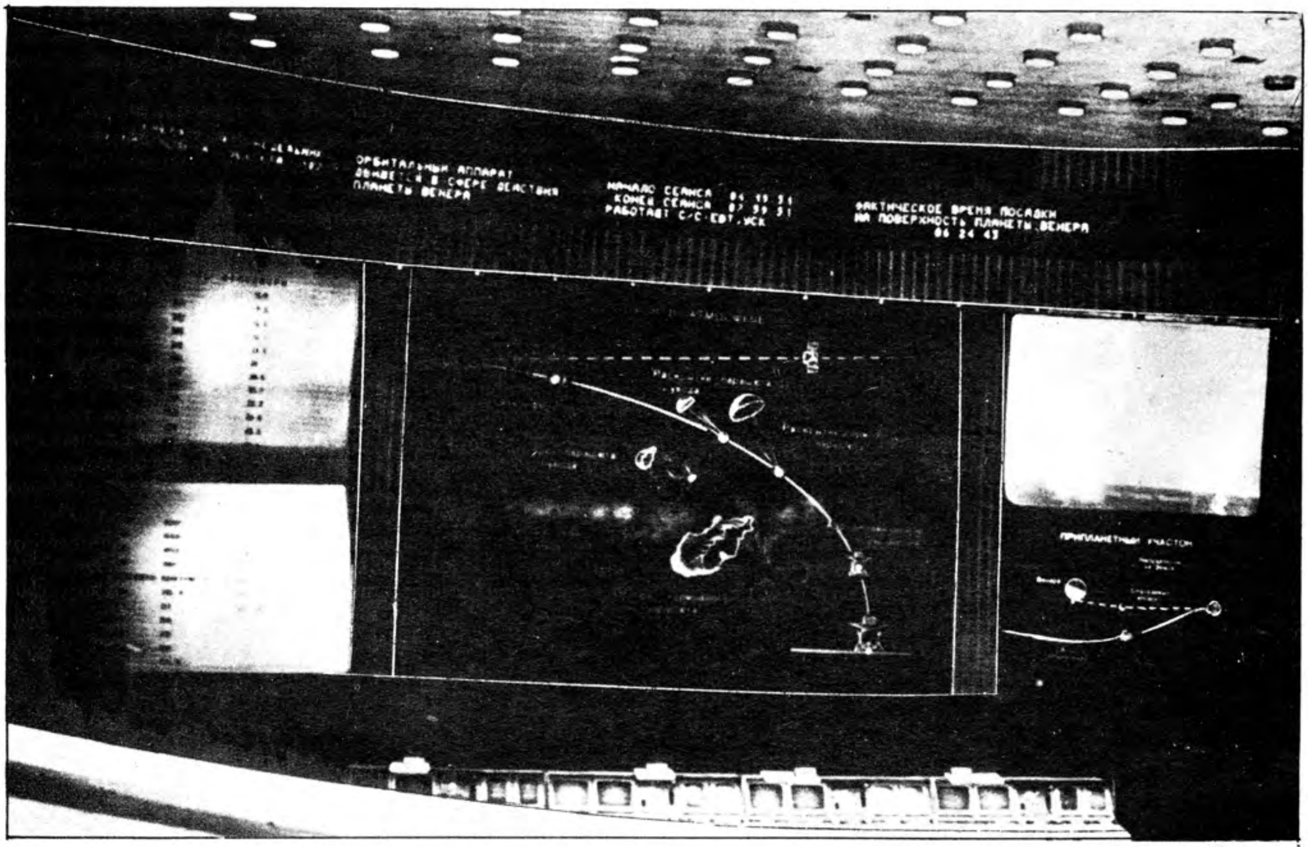
The composite package of three satellites in place will be subjected to vibration tests early in 1979, and would represent a tremendous step forward for the programme.

Dr. Lennertz emphasised that relations with India continue to be excellent and hoped that India would select the Ariane for commercial launches of its future satellites – the APPLE launch being a free entry ticket for future collaboration.

H. P. MAMA

GARP UNDERWAY

The world-wide meteorological measurement programme known as the First Global GARP Experiment (FGGE) began on 1 December 1978 and will continue until the end of



Soviet Flight Control Center on Christmas Day 1978 at the time of the entry into the atmosphere of Venus of the Venera 11 landing module. The module had separated from the mothercraft two days earlier. The latter was diverted to pass the planet at a distance of some 35,000 km.

Novosti Press Agency

November. This ambitious international effort involves no fewer than 149 countries in a programme coordinated by the World Meteorological Organisation (WMO). Taking part are:

- 9,200 ground-based stations
- 7,000 ships
- 80 scheduled aircraft
- 5 geostationary satellites
- 4 satellites in polar orbit

The Service ARGOS data processing centre, located at the CNES Toulouse Space Centre, keeps regular track of the ships which have been deploying drifting buoys at a rate of one every 1,000 km throughout the waters of the southern hemisphere. When all the 400 buoys of this network have been deployed, meteorological measurement data (buoy position, air pressure and temperature) will be continuously available for the whole southern hemisphere for the first time, and this will remain the case for a full year.

A second network is now being deployed in the Equatorial zone, comprising 300 balloons designed to float at an altitude of 14 km. Information concerning the winds at this level will be deduced by studying balloon movements. A first group of balloons deployed as a trial at the end of last year was tracked by satellite. Some were found to have circled the world.

Other networks involving balloons, buoys and icebergs are becoming operational. By the time all networks are active, Service ARGOS will be handling a total of over 1,000 platforms representing an investment of more than FF40 million.

The NASA/NOAA TIROS-N satellite, equipped with the French ARGOS data collection and platform location equipment package, was launched on 13 October 1978. A second satellite of this type, designated NOAA-A, should be launched this month.

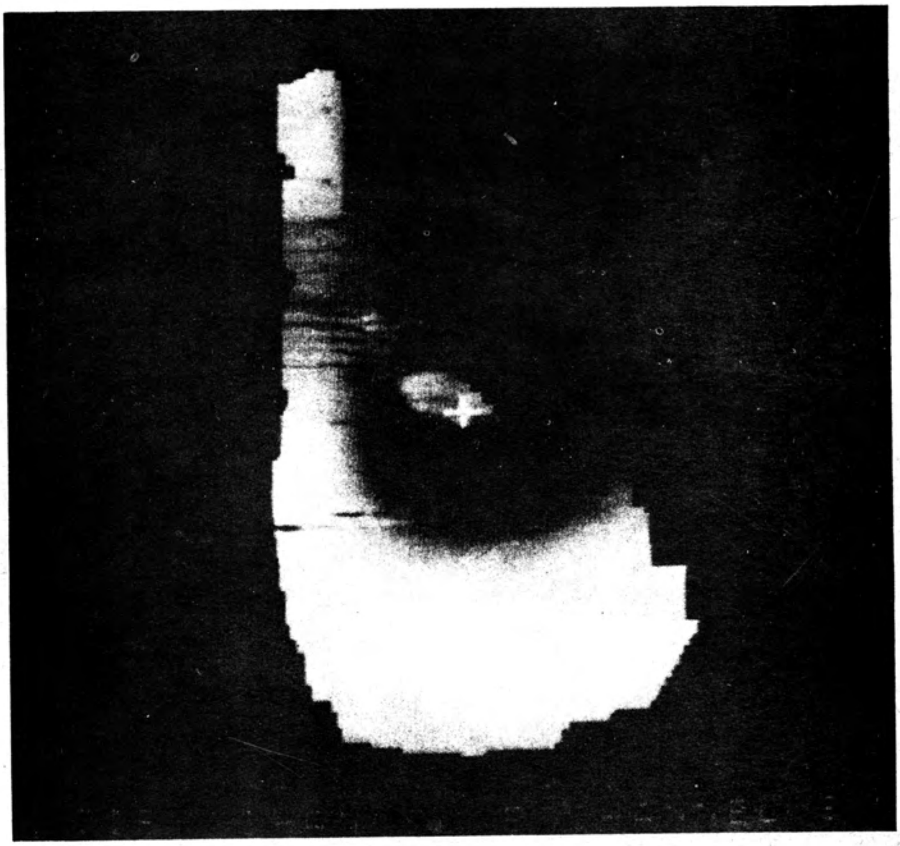
RUSSIAN PROBES ON VENUS

The landing capsules released by Veneras 12 and 11 two days before they made their close approaches to Venus in December appear to have produced significant results.

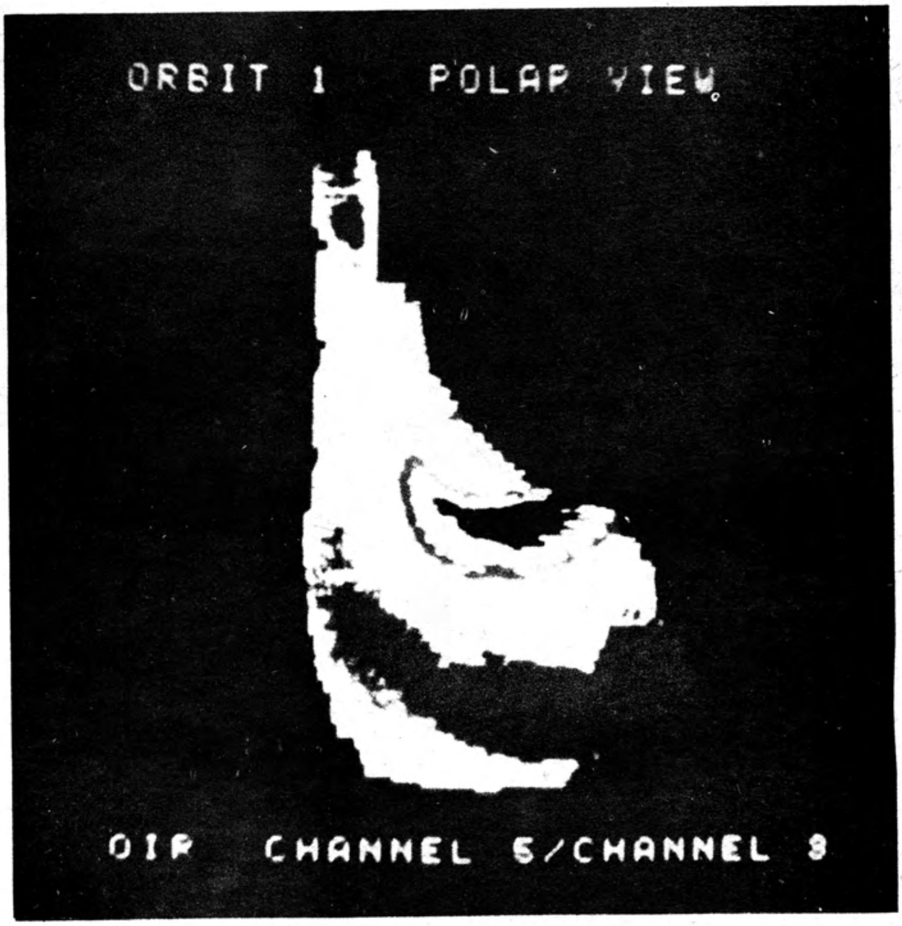
For example, carbon monoxide was discovered in the atmosphere using gas chromatographs landed in the probes. Gas chromatographs are normally fairly bulky instruments, but the specially designed ones used for this experiment weighed only about 10 kg.

Nine samples of the Venerian atmosphere were taken at intervals along the descent path. They confirmed previous data that the basic components of the atmosphere are carbon dioxide and nitrogen. The major discovery was the presence of relatively large amounts of argon which is important to an understanding of the planet's evolution.

Tass reported that the modules landed "in the calculated squares" some 800 km apart. Venera 11 became the tenth apparatus to have descended into the atmosphere or operated



First image of Venus' northern hemisphere obtained by the Infrared Radiometer aboard the Pioneer-Venus spacecraft on 5 December 1978. The white cross at the centre marks the position of the north pole. The radiometer measures the intensity of thermal emission from planet and atmosphere, and therefore is able to 'see' both the daytime and night-time sides. The partial coverage seen in this polar view shows a dark, cool cloud band near the pole. The polar temperature is measured to be -30°C, 20°C warmer than the equator and 30°C warmer than the nearby cloud band. *Below*, computer enhancement of this image reveals details which may be correlated with Venus' UV markings.



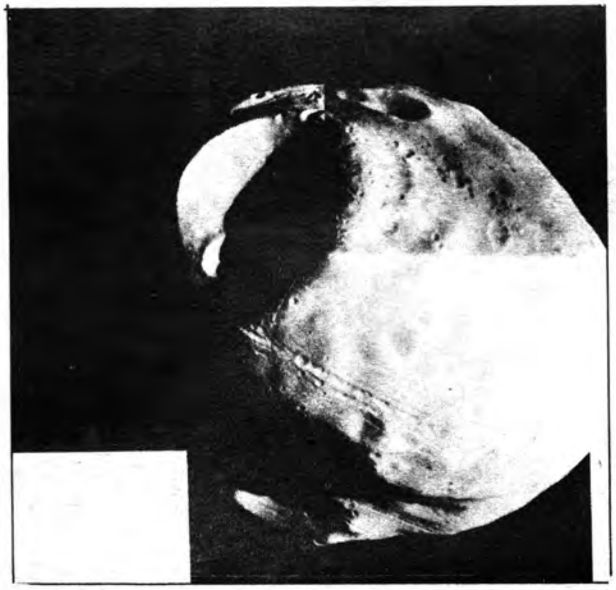
BALLOONS OVER VENUS

More details of the project to float balloons in the atmosphere of Venus are contained in a paper by M. Rougeron of the Centre Spatiale de Toulouse, a branch of the Centre National d'Etudes Spatiales.

The experiment is being developed in cooperation with the USSR Academy of Sciences which will incorporate balloons in the 1984 Venera probes. As previously reported (*Spaceflight*, March 1979, p. 98) the balloons are intended to break out and inflate from a split, spherical canister ejected from the Soviet spacecraft. Released from the canister at a height of some 60 km, they will drop another 11 km before becoming fully inflated. They are then expected to drift up to a height of some 56 km, their operational "ceiling".

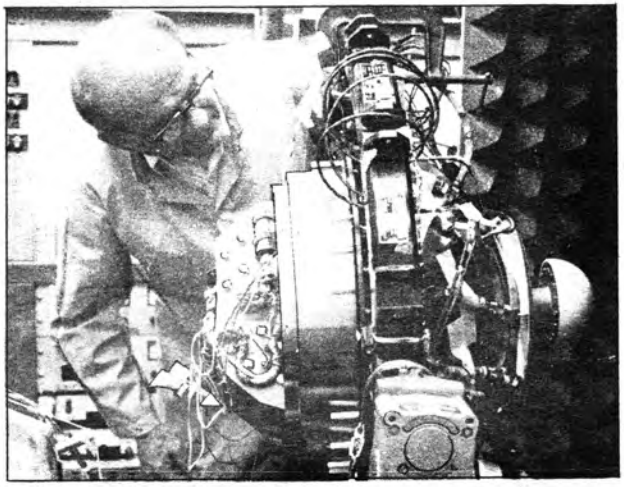
Each nine metre diameter balloon will carry an instrument package weighing about 250 kg. The envelope material is a composite comprising, from the inside out: Kevlar of about 110-160 g/m^2, a gas barrier of 12 microns thickness, aluminised polyester or polyamide, and a protective coating, also aluminised inside for thermo-optical balance, required by concentrations of sulphuric acid in the Venerian atmosphere.

The adhesive and welding for the mechanical assembly must be thermally stable due to high temperatures expected on the bright side of the planet. A Kevlar and Nomex band will be used on the interior and an exterior band will assure gas-tightness. The Venerian balloons will operate at a density altitude of 1 kg/m^3 or 0.062 lb/ft^3.



MARTIAN MOON. Phobos was photographed at a distance of 612 km on 19 October 1978 by Viking Orbiter 1 during the spacecraft's 854th revolution of Mars. These pictures were taken just before Phobos entered the shadow of the planet. The photomosaic shows the front side of Phobos which always faces Mars from about 10 deg below the equator with North at the top. Stickney, the largest crater on Phobos (10 km across), is at the left near the morning terminator. Linear grooves coming from and passing through Stickney appear to be fractures in the surface caused by the impact which formed the crater. This view provides new high-resolution coverage of the front side of Phobos approximately 19 by 22 km as seen here as well as the highest resolution yet of the Western wall of Stickney. Kepler Ridge is casting a shadow in the southern hemisphere which partially covers the large crater, Hall, at the bottom. Orbiter 1 has been orbiting Mars since 19 June 1976, and has taken more than 24,100 pictures of the planet and its two moons. An additional 16,525 pictures were taken by Viking Orbiter 2 from 7 August 1976 until 25 July 1978.

National Aeronautics and Space Administration



VENUS PROBE. Checking radio equipment of one of the American space probes which penetrated the atmosphere of Venus on 9 December 1978. Part of the exercise was to compare weather conditions on Earth and Venus. An article on this subject will appear next month.

Hughes Aircraft Company

SPACE TELESCOPE

A huge primary mirror blank which will become the major optical element of NASA's Space Telescope has been delivered to the Perkin-Elmer Corporation at Danbury, Connecticut, where the laborious two-year-long process of grinding and polishing is now getting underway.

The Space Telescope, a multi-purpose optical telescope planned for launch into Earth orbit in 1983 aboard the Space Shuttle, will enable scientists to penetrate seven times farther into space than is now possible, perhaps even to the outer edges of the observable Universe.

Marshall Space Flight Center has overall management responsibility for the project, while the Goddard Space Flight Center is responsible for the scientific instruments and planning telescope operations.

The 8 ft. diameter (2.4 metre) mirror blank was manufactured by Corning Glass Works in Canton, New York, under contract to Perkin-Elmer, prime contractor for the instrument's Optical Telescope Assembly (OTA).

The OTA will contain, in addition to the large precision optical system, special sensors to stabilise it on its astronomical target, the structure to support and align each of five scientific instruments to the telescope focal plane and sensors to control alignment of the telescope during its projected 15 years in orbit.

The Space Telescope will circle the Earth in a 320 nautical mile (600 kilometre) orbit and will provide views of stars, nebulae, and galaxies formed over 14,000 million years ago. Its position outside the turbulence and absorption of the Earth's atmosphere will permit observation of fainter and more distant objects impossible with any Earth-based telescope.

Corning Glass Works is the same company that made the 200 in. mirror for the Hale Telescope on Mt. Palomar. The Space Telescope mirror, unlike the 200 in. mirror which was cast in one piece by pouring molten glass into a mould, uses a lightweight design of an "egg crate" core fused between a front and back plate.

The Space Telescope mirror is made of ultra-low expansion glass; its reflecting face will be precision-polished to an aperture of 94 in. The mirror is about one foot thick with a centre hole about two feet in diameter, and in its unpolished state weighs 3000 lb.

At Perkin-Elmer, the primary mirror blank will go through various lengthy stages of grinding and polishing. Following

these initial operations, the mirror will be figured (polished) on a unique machine developed by Perkin-Elmer called the Computer Controlled Polisher. After final polishing and testing, it will be placed in a large vacuum chamber and its front surface coated with a thin reflective film. In its finished state, the mirror will weigh approximately 1,650 lb.

Perkin-Elmer has produced large-aperture telescopes for over 40 major observatories throughout the world, and in 1957 built the first telescope flown above the Earth's atmosphere, the balloon-borne Stratoscope I, with a 12 in. mirror.

VANGUARD RETIRES FROM NASA

After 12 years of supporting Apollo, Skylab and Apollo-Soyuz manned space flight missions, the *USNS Vanguard*, last of an original five-ship tracking and re-entry coverage flotilla, was transferred on 1 October 1978 to the United States Navy for navigational and ocean survey work.

Vanguard served NASA astronauts throughout ten Apollo, four Skylab and one Apollo-Soyuz mission as a floating tracking station, carrying out assignments in the Atlantic, Indian and Pacific Oceans.

NASA LAUNCH SCHEDULE

Eleven of the 16 launches on NASA's schedule for 1979 are reimbursables, satellites launched by NASA for other agencies or corporations.

The space agency's activities will include the first launch and orbital flight of the crew-carrying Space Shuttle; Jupiter and Saturn encounters by two Voyager spacecraft; and a flyby of the rings of Saturn by the Pioneer 11 spacecraft.

Three launch sites will be used: Cape Canaveral, Florida, Vandenberg Air Force Base, California and Wallops Island, Virginia.

As was the case in 1978, most of the 1979 launches emphasise the use of space for the direct benefit of people on Earth – communications and environmental and meteorological information. During 1978, the agency logged 20 launches, 11 of them reimbursables for paying customers. Paying customers for 1979 launches include the Department of Defense, the National Oceanic and Atmospheric Administration (NOAA), the United Kingdom, Western Union Corporation, Comsat Corporation and RCA.

The first orbital flight of the Space Shuttle, NASA's reusable space transportation vehicle, is scheduled before the end of 1979. Astronauts John Young and Robert Crippen have been named as crew members on the first flight which will be launched from Kennedy Space Center, Florida, and land about 53 hours later at the NASA Dryden Flight Research Center, Edwards, California.

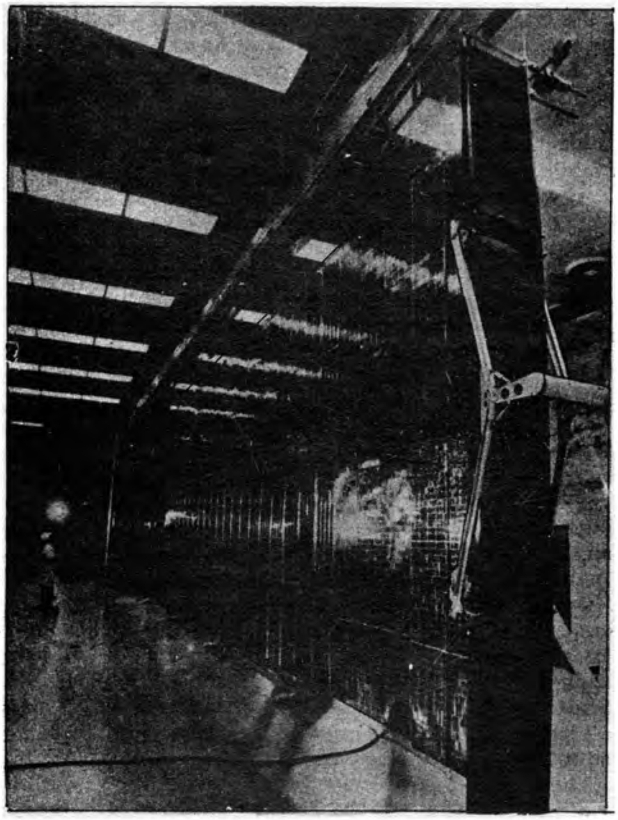
On 5 March 1979, the Voyager 1 spacecraft, launched from Earth on 5 September 1977, is scheduled to make its closest approach to the planet Jupiter and travel on to make a close approach to the planet Saturn on 12 November 1980. Its sister craft, Voyager 2, which was launched on 20 August 1977, makes its closest approach to Jupiter on 9 July 1979, and to Saturn on 27 August 1981.

The Pioneer 11 spacecraft, launched on 6 April 1973, on its primary mission to fly by Jupiter, is scheduled to make its closest approach to the rings of Saturn on 1 September 1979.

1979 Expendable Vehicles Launch Schedule

Launch Date	Mission Designation	Launch Vehicle	Launch Site*	Mission Description
January 30	SCATHA	Delta	ETR	DOD (R & D) Space Charging at High Altitudes – reimbursable
February 18	SAGE-A	Scout	WFC	NASA (applications) Stratospheric Aerosol and Gas Experiment
April	NOAA-A	Atlas-F	WTR	NOAA (weather) – reimbursable
April	Navy-20 C/U	Scout	WTR	DOD Transit – reimbursable
May	FLTSATCOM-B	Atlas Centaur	ETR	DOD (Navy/Air Force communications) – reimbursable
June	UK-6	Scout	WFC	UK (scientific) – reimbursable
July	Westar-C C/U	Delta	ETR	Western Union (communications) – reimbursable
August	Intelsat V-A	Atlas Centaur	ETR	Intelsat (communications) – reimbursable
September	HEAO-C	Atlas Centaur	ETR	NASA (scientific) High Energy Astronomy Observatory
September	Magsat-A	Scout	WTR	NASA (applications) Magnetic Field Satellite
October	SMM-A	Delta	ETR	NASA (scientific) Solar Maximum Mission
October	Navy-21	Scout	WTR	DOD Transit (NOVA I) – reimbursable
November	Intelsat V-B	Atlas Centaur	ETR	Intelsat (communications) – reimbursable
December	NOAA-B	Atlas-F	WTR	NOAA (weather) – reimbursable
December	RCA-C	Delta	ETR	RCA (communications) – reimbursable

* *ETR – Eastern Test Range, Cape Canaveral, Florida; WFC – Wallops Flight Center, Wallops Island, Virginia; WTR – Western Test Range, Vandenberg AFB, California.*



EXPERIMENTAL SOLAR 'WING' that will fly aboard NASA's Space Shuttle in the early 1980's is shown during a demonstration at Lockheed Missiles and Space Company, Sunnyvale, California. The accordian-like wing was extended and retracted, simulating what will take place during the test flight in orbit.

National Aeronautics and Space Administration

U.S. DEFENCE COMSATS

The latest pair of DSCS II satellites, DSCS 11 and 12, were launched by Titan 3C-30 from ETR on 14 December 1978 into synchronous near-equatorial orbits, writes Andrew Wilson. The Defense Satellite Communications System (DSCS) is operated by the Defense Communications Agency to provide long haul communications services throughout the Department of Defense (DoD) and links elements of the national military command, including national command authorities and mobile users. The drum shaped satellites, built by TRW Defense and Space Systems for the Air Force Space and Missile Systems Organisation (SAMSO), stand 13 ft (396 cm) high and have diameters of 9 ft (274 cm). Each weighs 1300 lb (590 kg).

Four antennae, comprising two horns and two 44 in (112 cm) dishes mounted on a despun platform controlled by signals from infra-red Earth sensors, provide communications capacity of 1300 duplex voice channels or a data rate of up to 100 megabits/s. Solar panels yield 535 watts of power after launch, dropping to 358 watts at the end of five years, still adequate for the communications demand of 235 watts.

The DSCS phase II satellites replace the initial defence comsat system of 26 IDSCS (Initial Defense Satellite Communication System) spacecraft launched during 1966-1968 with design lives of three years, although this figure was easily exceeded by some of the satellites. The first DSCS II spacecraft with greatly extended lifetimes and capabilities over the first series were launched in November 1971, into geostationary orbits but subsequent flights have not been too successful. The third pair, DSCS 5 and 6, were launched in May 1975, by Titan 3C-22 but the transtage failed and the spacecraft went into low Earth orbit instead of entering the planned geostationary orbits over the Atlantic and Pacific Oceans. The payloads re-entered five days later. In March, 1978 DSCS 9 and 10 were lost when Titan 3C-28 veered off course and had to be destroyed.

The initial series was not without failures either – eight satellites were lost in August, 1966 when Titan 3C-5 failed to achieve orbit.

The series has been disappointing in its results and DoD has been forced to borrow communications capacity off the Nato 2 and 3A satellites.

A third phase, DSCS III, is planned for the near future with spacecraft which will hopefully have operational lifetimes of 10 years and use three-axis stabilisation. General Electric won the contract for one qualification and two flight units against competition from the Hughes Aircraft Company and if the vehicles perform satisfactorily after launch in 1979 and 1980 a new communications system will be set up.

One suggestion put forward to Nato is to adopt DSCS III-type spacecraft for the Nato 4 series of military comsats.

Four further DSCS II satellites with increased capabilities over those just launched have been ordered from TRW.

Previous DSCS flights are:

DSCS 1 & 2	launched	3 Nov 1971
DSCS 3 & 4		13 Dec 1973
DSCS 5 & 6		20 May 1975
DSCS 7 & 8		10 May 1977
DSCS 9 & 10		25 Mar 1978

The IDSCS flights were:

IDSCS 1-7	launched	16 Jun 1966
IDSCS 8-15		18 Jan 1967
IDSCS 16-18		1 July 1967
IDSCS 19-26		13 Jun 1968

SALYUT 6: THE LONG-STAY COSMONAUTS

Soviet cosmonauts Vladimir Kovalenok and Aleksander Ivanchenkov who returned to Earth on 2 November 1978 after an orbital flight lasting 139 days 14 hours and 28 minutes took only 10 days to readapt themselves to the force of gravity. This result is encouraging for the longer flights now being planned, writes Neville Kidger.

At a press conference on 16 November at Moscow University, Professor Oleg Gazenko gave details about the flight and assessed the medical results and their implications. He reported that the crew had not only fulfilled their planned scientific programme, but on many important aspects had exceeded it. This applied in particular to the medical and biological research programmes. The programme of work was described as being exceptionally broad, variegated and intense, "as well as carrying out various technical tests on the various and numerous systems on board the orbital complex, work connected with the servicing of the station itself and constant communications with the Flight Control Centre (FCC). As time went on, the crew's work capacity increased in comparison with the initial flight period. There were several circumstances contributing to this fact.

"First there was the punctual fulfillment by the crew of the work and rest regimen which they helped to draw up. There was wider crew participation than had previously been the case in the planning of future operations. There was the quite rapid and successful adaptation by the crewmen to the

unique conditions of weightlessness. The normal adaptation to weightlessness – is manifested – by a number of not very pleasant sensations – (such as) a flow of blood to the head and the appearance of various vestibular disorders. In practice it was without any unpleasant sensations, apart from sensing a certain flow of blood to the head, and was completed in the first two or three days. This may be explained by certain individual physiological features of the men – and by the pre-flight training exercises.

"Throughout the flight detailed medical research was carried out on specially appointed days – both when the cosmonauts were in a state of 'relative rest', and when the crew were being tested under conditions of stress....The cosmonauts were exceptionally sensible and creative in carrying out their not always pleasant work. The crew took samples of their own blood and carried out biochemical research. They co-operated well with the FCC constantly showing a great interest in discussing the data obtained, and made constructive proposals for further research. The medical programme was complemented by certain new aspects which had not been present in previous flights (including) 'dynamic electro-cardiography', i.e. continuous round-the-clock recording of an electrocardiogram, which has considerably broadened our ideas of the reactions of the human body to the effect of flight conditions at different periods of flight.

"A great deal of other research was carried out, in particular, into such parameters as gustory sensitivity, hearing thresholds and many others. In these cases it proved possible to deliver certain samples and results of analysis to Earth, which considerably increased the possibility, breadth and scope of appropriate analytical work on Earth and ensured that the results obtained were more valuable. Previous flights revealed that prolonged effects of weightlessness could have an adverse effect on a whole series of systems of the body – primarily the cardio-vascular and supportive muscular systems, the metabolism and state of the blood.

"The frequent electrocardiographic research conducted throughout the flight did not show any deviations from the norm. Functional tests at dosed physical levels and with the application of negative pressure to the lower part of the body (using the 'Chibis'-suit) also showed that these reactions were adequate and, most important of all, that no negative dynamic was noted. With the passage of time the responses to these tests did not worsen. The objective signs of redistribution of the blood, revealed by rheography, were observed with particular acuity during the initial phase of the flight. It was possible to register these signs in the overfulfilling of the vessels of the head and upper part of the body and the depletion of the blood vessels in the lowest part of the body, particularly in the legs. These readings averaged out somewhat in the middle part of the flight, but all the same persisted to the end. This did not cause the cosmonauts any unpleasant personal sensations.

"As the crew became accustomed to weightlessness, a new co-ordination of motion became established, which provided sufficient efficiency for the fulfillment of all necessary operations. An analysis, conducted of the TV images obtained from the Salyut 6 station, indicated that by the end of the first month these movements were being carried out rapidly, precisely and with confidence. Simutaneously, with the passage of time, a reduction in the volume of the lower limbs was registered, which indicates the loss of a certain part of the fluid component.

"Thanks to the use of the measurement of the mass of the body it was possible to obtain an impression of the dynamics of weight and in a certain way to regulate this parameter by alterations to the quantity of food and water intake. However it was still not possible to stabilise their weight completely, and it fell to a certain extent – to a greater degree in the case of Ivanchenkov.

"Study of the blood state was of particular interest to the medical monitoring team. The average duration of life of the erythrocytes, i.e. the red blood cells, is 120 days. In the course of 120 days our red blood cells are completely changed. From experiments conducted during previous space flights it was known that in the course of a space flight of even shorter duration there is a reduction in the number of these cells, which are very important to us. They are, as it were, the carriers of oxygen in the tissues of our body. Therefore research into the blood system was of great importance, and I can report that the control samples which were taken by the cosmonauts themselves during the flight and were delivered to Earth and subjected to appropriate analysis showed only a very moderate reduction in the number of erythrocytes and haemoglobin – considerably less than the values that we had obtained earlier, even in shorter flights.

"Specialists who have analysed this information believe that this obviously positive result can be connected with the fact that the cosmonauts did, apparently, lose less of their circulatory blood than those who had flown earlier, which was probably partially ensured by the fact that they maintained the consumption of water at a sufficiently satisfactory level and fulfilled an adequate amount of physical exercise (up to two hours per day in the 'Chibis' suit) which assisted the preservation of the volume of the red-cell mass of blood.

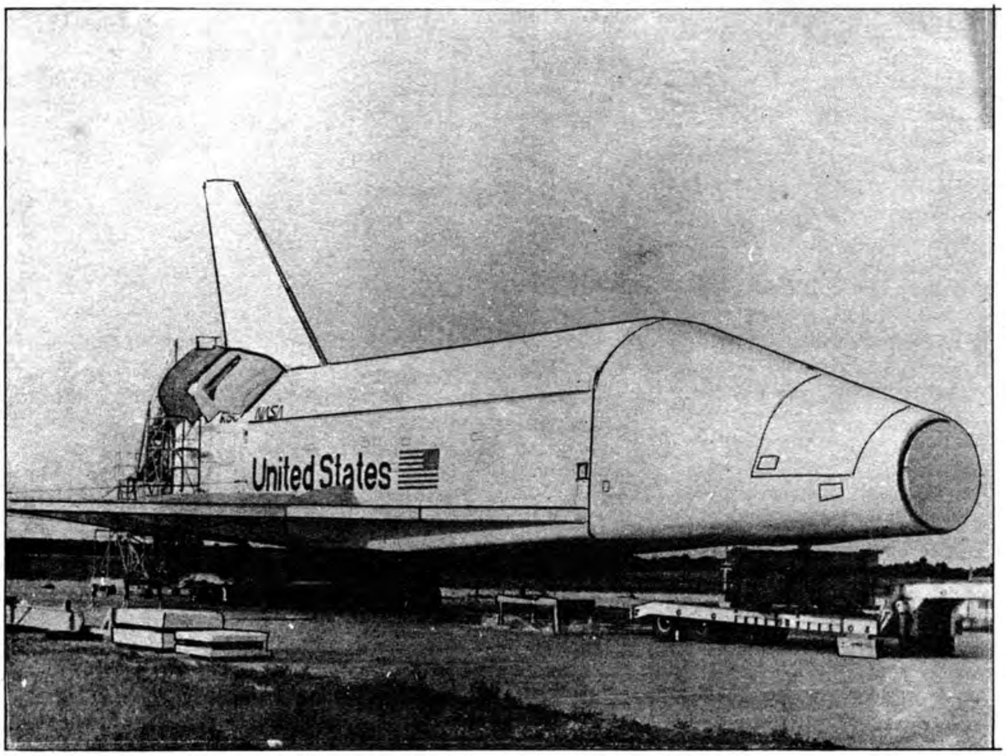
"Physical exercises....(were) carried out practically every day throughout the prolonged flight. Had they been running the speed would have been 8-9 km/hr....If we were to convert this into useful work from the point of view of looking after oneself, then the energy for this would be equal to the amount needed to heat a two litre kettle to boiling point, or equivalent to climbing a skyscraper over 200 floors high, or lighting one's flat with a good bulb for two hours.

"The cosmonauts displayed a great sense of observation, collecting a great deal of interesting and important data. Further analysis of this, together with proposals by the cosmonauts themselves, will undoubtedly help improve the methods of maintaining man's physiological organism in future prolonged space flights....It was precisely this adherence to the daily programme by the crew, with a sufficiently elastic and variable planning of work with combined meticulous adherence to the appropriate preventative and sanitary-hygienic measures, which helped the crew preserve good health, high working ability and even calmness....Personnel of the FCC and psychologists (attach) great importance to the optimisation of communications between the ground and the station and the (implementation) of measures which were termed as psychological support.

"Special issues of newspapers and videotapes with family chronicals of events, concerts and the like were taken on board. Periodical radio conversations with members of families, friends and interesting conversationalists and various performers were organised....This undoubtedly contributed to maintaining the high spirits of the crew....Various kinds of food (such as) fresh vegetables and fruit were brought by visiting expeditions and transport craft.

"After the landing the cosmonauts' reactions (to Earth conditions) were less pronounced than had been the case during previous, shorter flights. Thus the apparent increase in the weight of one's own body and all the objects one meets when back on Earth, such as ungainly movements and difficulties with co-ordination were observed only on the day the flight ended. Later the cosmonauts did not experience any kind of personal difficulties. On the first day after the flight the loss of weight was 2.3 kg for Kovalenok and 3.9 kg for Ivanchenkov. Recovery of weight by Kovalenok was completed on the third day but Ivanchenkov's weight has not yet been fully restored (as at 16 November).

"Blood changes were manifested only in a very insignificant lowering of the number of the red blood cells and haemoglobin with an inclination towards the diminution of the size of these cells while practically retaining their shape, but the changes which did take place were of no practical significance. The number of white blood cells increased



SHUTTLE MOCKUP. Just as the launch and handling facilities at the Kennedy Space Center were checked out with a full size engineering model of Saturn 5, so a mockup of the Shuttle Orbiter has been provided for use in the flight preparation programme. This picture was taken on 29 June last year when the mockup stood in the shadow of the Vehicle Assembly Building. The wooden framework for the Orbital Manoeuvring System pod is still under construction.

Andrew Wilson

..., but the content and the level of discharge of the steroid hormones rose somewhat, which is an indication of a tension reaction, quite natural in a situation of this kind. Stability with regard to orthostatic influence, that is the changes of the body in space and to physical stresses, diminished, but to a relatively smaller degree than could be registered after flights of shorter duration. Research carried out with the help of ultrasonic electro-cardiography did not reveal any pathological changes, even though the quantity of the blood, which the heart pumps out with every beat, had diminished, but not more, or even to a less extent, than we had previously recorded.

"The greatest attention, against the background of the good condition of the cosmonauts, was drawn to changes in the sphere of motion. They manifested themselves, first of all, in symptoms of atrophy and atonicity, and also in a heightened reflex response to irritation of the muscles. The perimeters of the hips of Kovalenok and Ivanchenkov were diminished by about 1.5 cm and 4 cm respectively. These changes were, we suppose, the results of their adaptation to weightlessness....From their first day back on Earth the cosmonauts have been active. Their locomotion regimen was gradually increased....Their main problem has been to restrain somewhat that motor activity. In order to ease their readaptation to Earth gravity specialists have been carrying out relevant measures envisaged for this event: healing massage, walks of variable length, swimming in the pool and so on. The cosmonauts did not require any medicines. The 'severe period' of readaptation seems to have taken no more than three to four days, which is an extremely good result".

See footnote on page 202. Ed.

SHUTTLE VIBRATION TESTING

In the early analysis of test results, two primary deviations have been discovered. One concerns excessive movements in a forward section of the Solid Rocket Boosters where guidance gyros are located and a second involves the transfer of loads, or forces, at the attach points between the boosters and the External Tank.

Brackets to strengthen the boosters where the gyros are located will be installed and individual tests on that particular portion of the boosters will be conducted at a test facility used for smaller components.

Additional studies of test data are planned to analyse the load distribution at the attach points and to determine if additional tests are necessary.

During the recently completed test phase, engineers found that about 80 percent of the test modes verified analytical predictions of how the hardware will react during flight.

The final phase of testing begun early this year simulates the configuration of the Shuttle just prior to the burnout and separation of the Solid Rocket Boosters at an altitude of about 43.5 km (27 miles).

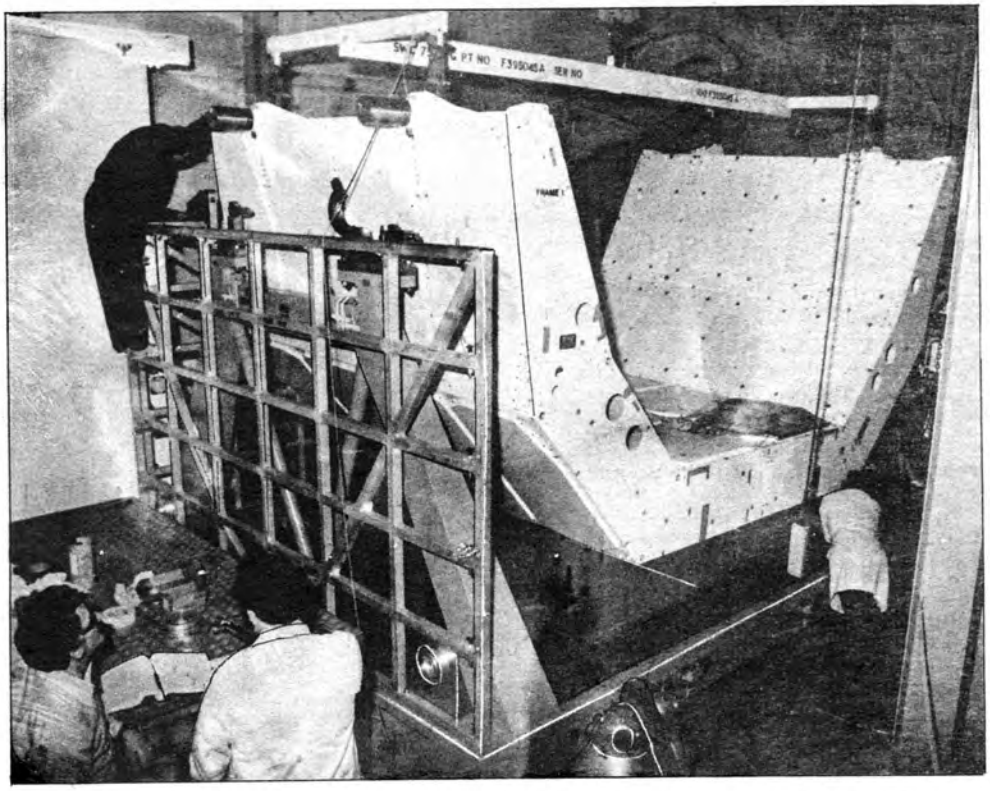
SPACELAB EXPERIMENTS PALLET

The first Spacelab pallet scheduled to fly in the Shuttle Orbiter has now arrived at the Kennedy Space Center. It was despatched last December from the Stevenage space facility of British Aerospace Dynamics Group to the European Spacelab consortium prime contractor ERNO of West Germany from where it was shipped to Cape Canaveral.

Spacelab pallets are being designed and built for the nine-nation Spacelab consortium by BAe Dynamics Group at Stevenage under contract to the European Space Agency. To date two hard mockups, five development models and two engineering models have been completed. Under the present contract, one further engineering model and five flight models are yet to be delivered, although it is hoped that further flight models will be ordered.

Extensive structural tests have been completed successfully on development models both at Hatfield and Cranfield and integration tests have been carried out by ERNO.

Dynamics Group has also investigated ways of improving the capability of the pallets by the addition of more hard points and by offering bridge and platform systems for



The first Spacelab pallet due to fly in the NASA Space Shuttle Orbiter ready for despatch from British Aerospace Dynamics Group, Stevenage, England.

British Aerospace Dynamics Group

smaller experiments. The Group has also considered half or quarter length pallets and has carried out studies on a small experiment pointing mechanism which would be controlled from the manned Spacelab module.

TRAINING FOR SPACELAB

Five European and American scientists selected last July to operate the experiments on NASA's first Spacelab mission began training in the United States in January. The training tour, which took them to seven U.S. cities and two in Canada, will prepare them to operate the equipment associated with the scientific investigations previously identified to take place on the laboratory when it flies into Earth orbit aboard the Space Shuttle in 1981.

The selection and training of these scientists to fly in space represents a departure from earlier NASA practices. They are not career astronauts, and were chosen for the mission by the scientists who devised the experiments to be flown. This will also be the first time that Western Europeans will fly in space and the first time that NASA will have orbited people from a country other than the United States.

Three of the Payload Specialists, as they are called, are from Europe. The first Spacelab mission, like the building of Spacelab itself, is a joint venture of NASA and the European Space Agency (ESA). Of the five men training for the mission, two – a European and an American – will actually go into space aboard Spacelab 1. The other three will operate the ground-based experiment equipment and will support the two in orbit. Selection of the Payload Specialists who will actually fly will not be made until later in the training cycle.

The Payload Specialists for Spacelab 1 are:

- *Michael L. Lampton,* University of California, Berkeley.
- *Byron K. Lichtenberg,* Massachusetts Institute of Technology.
- *Ulf Merbold,* German, Max Planck Institute, Stuttgart.
- *Claude Nicollier,* Swiss, European Space Technology Center.
- *Wubbo Ockels,* Dutch, Groanigan University, Netherlands.

Nicollier is a Fellow of the British Interplanetary Society. All five recently returned from Europe, where they had been in training since October, learning to operate the experiments which will be placed on Spacelab by European scientists.

The Payload Specialists began their first American training tour on 9 January with a four-day session at NASA's Marshall Space Flight Center in Huntsville, Alabama. The Marshall Center is NASA's lead centre in the development of Spacelab itself, and is managing the first three missions.

After leaving Huntsville the Payload Specialists continued their training schedule in the following locations.

Redondo Beach, California; Huntsville, Alabama; Houston, Texas (Johnson Space Flight Center); Philadelphia, Pennsylvania; Boston, Massachusetts; Montreal, Canada; Toronto, Canada; Houston, Texas and Palo Alto, California. They returned to Huntsville on 22 March.

Forty instruments will be flown aboard Spacelab 1. The science payload is about equally divided between NASA and ESA experiments in terms of weight, power, and volume requirements. Investigations will be conducted in stratospheric and upper atmospheric physics, materials processing, space plasma physics, biology, medicine, astronomy, solar physics, Earth observations and in technology areas such as thermodynamics and lubrications.

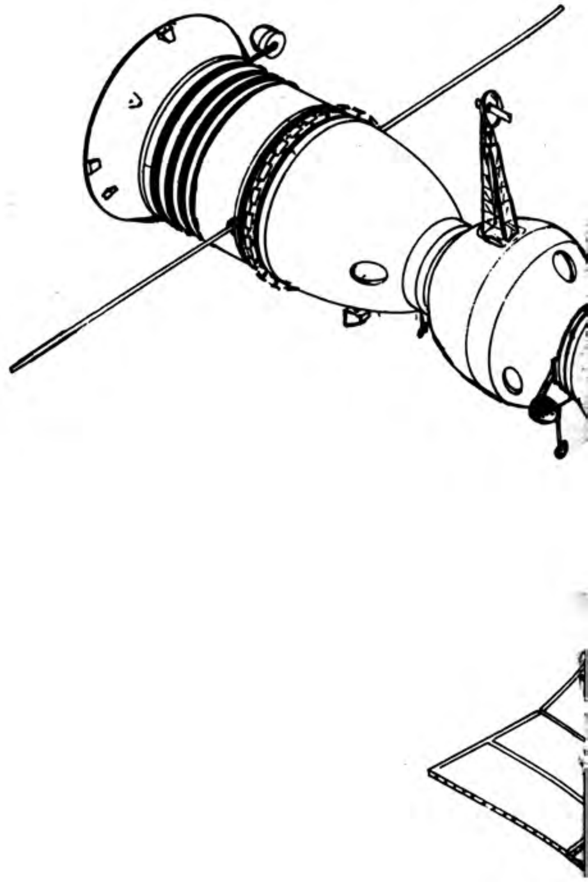
The Marshall Center manages training activities in the U.S. as part of its overall management responsibility for the first three Spacelab missions. ESA manages training activities in Europe.

MISSIONS TO SALYUT 6

[Continued from March issue, p.

PART 6

By Gordon R. Hooper



SALYUT 6 SPACE STATION with Soyuz spacecraft (top left) and Progress au

Progress 2

On 7 July 1978, at 11.26 (all times expressed in GMT) the Soviet Union launched the unmanned Progress 2 supply craft. At the time of lift-off, Salyut 6 was approximately 20,000 km (12,428 miles) away. Following orbital insertion, the parameters of the Progress craft's orbit were 262 x 193 km (163 x 120 miles) x 88.7 min. x 51.6°.

The purpose of the mission was to deliver to the Salyut a 50 day supply of food, water and air. Progress 2 carried 200 kg (441 lb) of water, 250 kg (551 lb) of food and various equipment, together with several hundred kilogrames of propellant. It also carried air regeneration units, and additional units for the on board computer.

On board the Salyut, the crew of Vladimir Kovalyonok and Alexander Ivanchenkov spent the day on medical experiments. They conducted investigations into the bioelectrical activity of the heart, the dynamics of the blood's circulatory system during rest, and also complex investigations into the central nervous system.

At a press conference in Moscow, attended by over 200 Soviet and Polish journalists, together with foreign correspondents accredited in Moscow, Boris Petrov said the flight of Kovalyonok and Ivanchenkov would be a long one. The conference was also attended by the Soyuz 30 crew. Pyotr Klimuk underlined the importance of the experiments in space medicine and psychology conducted by Polish specialists, whilst Miroslaw Hermaszewski expressed his great joy over being the first Pole to venture into outer space.

On 9 July, at 12.59, Progress 2 docked at the rear docking port of Salyut 6. The search, rendezvous and docking procedures were all carried out automatically. As well as the food and fuel supplies, the robot craft brought letters and gifts from the cosmonauts' families and friends. Also on board was a new electric furnace, an improved version of the Splav (Alloy) furnace already on board. The new furnace was known as the Krystall (Crystal) and the process of crystalization took place in the following manner.

The substance from which the crystal was to be formed was first placed in a zone where the temperature was reduced; a seedling (zatravka) technique was used which kept one side cold and the other hot. The cold side acted as a seed. The temperature curve was kept constant in space. The sample in the capsule then stretched slowly across the zone, with the same result as in Splav, but temperature control was better, giving crystals that were more regular and homogenous.

Krystall was said to be highly automated. It incorporated many kinds of electronic devices enabling the cosmonauts to select various work programmes without interfering in the processes. Whereas Splav was in the airlock chamber, so that heat could be discharged into open space, Krystall had better heat protection and was placed inside the station's cabin. There was a certain amount of heat from it, but the temperature control system was able to cope.

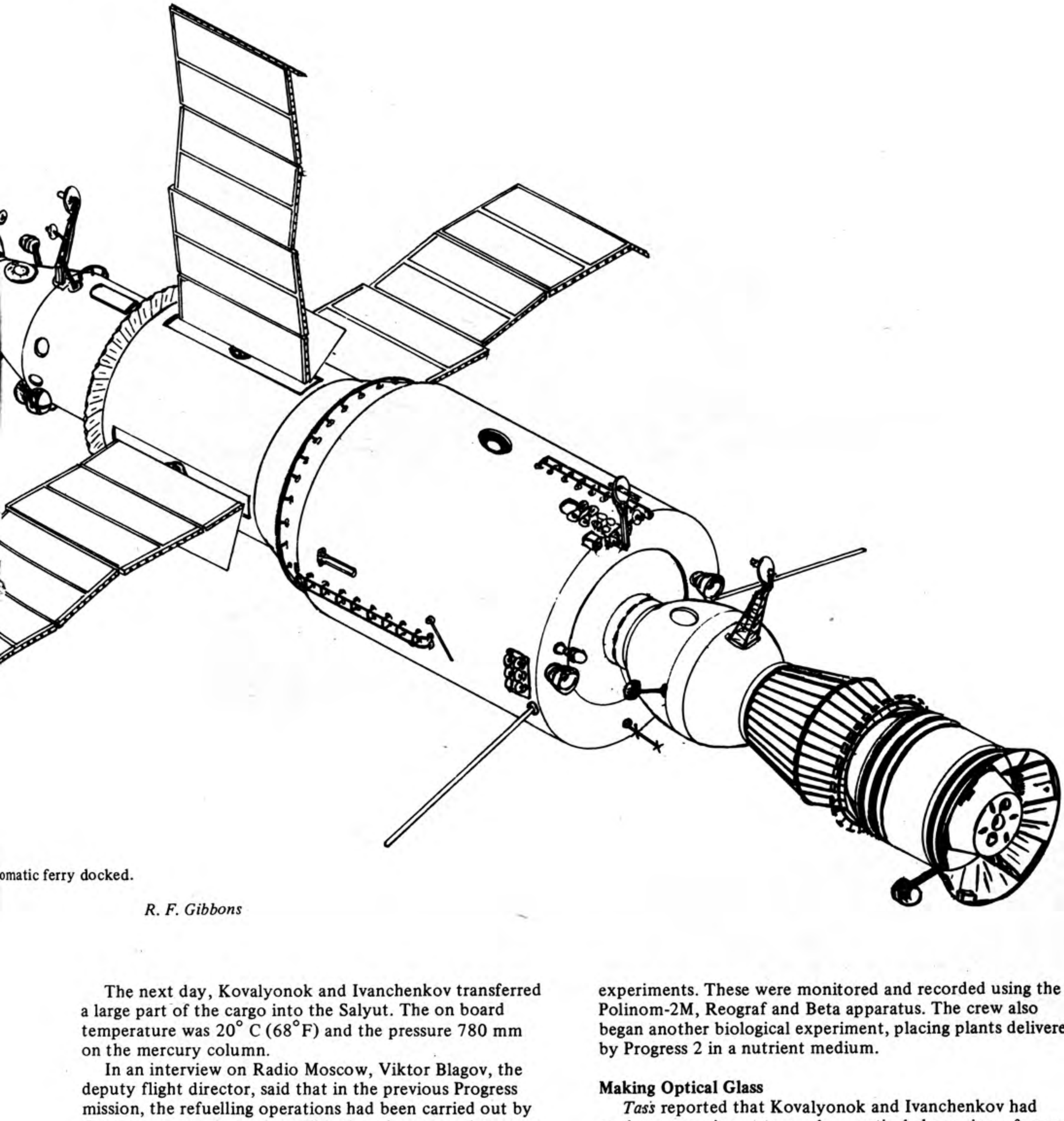
On 10 July, the cosmonauts began work on unloading Progress 2. Other work during the day included visual observations of the Earth, physical exercises and a TV report. They checked the spacecraft's systems and the airtightness of the docking assembly, before opening the hatch and entering the Progress to check the freight. In the afternoon, they started to unpack the various items and carried them into the Salyut. While they were doing this, MCC prepared the fuel tanks of the Salyut for refuelling.

An *Aviation Week and Space Technology* report revealed that following a series of Resonance experiments, the cosmonauts were prohibited from using the running track at certain speeds while two vehicles were docked to the Salyut, as potentially dangerous vibrations were set up.

In Moscow, Klimuk and Hermaszewski attended a meeting of the Soviet Polish Friendship Society, where they both gave short speeches.

On 11 July, the cosmonauts on board Salyut 6 continued to unload the Progress craft, while MCC continued the preparation of the station's fuel tanks for the transfer of fuel and oxidiser. According to Radio Moscow, the Progress cargo included over 100 kg (220 lb) of film. During the day, the cosmonauts had a communications session with Klimuk and Hermaszewski.

On 12 July, the work on unloading and fuel tank preparation was continued. In addition the crew checked spacecraft systems and did physical exercises. They also dismantled one of the life-support generators and replaced it with a new one delivered by Progress 2. The unloading was reported to be going ahead strictly according to schedule.



omatic ferry docked.

R. F. Gibbons

The next day, Kovalyonok and Ivanchenkov transferred a large part of the cargo into the Salyut. The on board temperature was 20° C (68°F) and the pressure 780 mm on the mercury column.

In an interview on Radio Moscow, Viktor Blagov, the deputy flight director, said that in the previous Progress mission, the refuelling operations had been carried out by the cosmonauts themselves. This time, however, they were being carried out by MCC, thus saving time. He added that the station's "Globus" (Globe) instrument panel had completed its working life and had ceased functioning. This had been replaced by a new Globus delivered by Progress 2. Its function was to indicate the station's position in relation to the Earth.

During the day, the cosmonauts reported flying over Africa, Europe, the Caucasus, and the Altai. For the first time, they had seen the Pamirs, usually covered by clouds. They had also seen Lake Baikal twice.

On 14 July, the cosmonauts carried out comprehensive physical examinations, performing graduated exercises on the cycle-ergometer as well as other medical checks and experiments. These were monitored and recorded using the Polinom-2M, Reograf and Beta apparatus. The crew also began another biological experiment, placing plants delivered by Progress 2 in a nutrient medium.

Making Optical Glass

Tass reported that Kovalyonok and Ivanchenkov had made an experiment to produce optical glass using a furnace delivered by Progress 2. The absence of gravity was expected to improve the microstructure of the glass and provide a surface that required no further treatment. Whereas difficulties were caused in manufacture on Earth by the molten glass touching the walls of the furnace, in space it was possible to carry out the melt and solidification in a state of suspension. The cosmonauts were, said *Tass*, "the first glassmakers in space."

On 15 July, the day was spent on physical exercises and in documenting the previous week's work. In addition, it was a cleaning day, and the men cleaned the holds and switched on the air filters. Medical reports showed that after a month in orbit, they had adapted well to weightlessness.

On 16 July, the crew had a rest day, read, listened to music, and talked to their friends and relatives assembled at MCC. In addition, the two men assembled and prepared the equipment for the first Krystall experiment.

On 17 July, Kovalyonok and Ivanchenkov carried out their first experiment with the Krystall furnace, located in the transfer section of Salyut 6. They used it to produce a pure monocrystal of gallium arsenide from a high temperature solution by a zone-melting technique. *Tass* reported that "this was the first time that a monocrystal had been formed in conditions of weightlessness by the movement of a capsule in an electric furnace."

Also during the day, the men carried out repair work and recharged photographic equipment for future experiments. A further Splav experiment was carried out in the afternoon, together with the continued unloading of Progress 2. The pulse rates of Kovalyonok and Ivanchenkov were respectively 65 and 60, whilst blood pressures were 120/65 and 130/60.

Water Regeneration

The improved water regeneration system installed on board Salyut 6 had lead to quite substantial improvements in the quality of the cosmonauts diets. The system provides the crew with drinking water and water to add to dehydrated foods. Versions of the unit were tested on Salyuts 4 and 5, but the unit on board Salyut 6 is considered to be more of an operational design. The system collects water from the air, separates it from the gas mixture, purifies it, and decontaminates and mineralizes it.

A cooling/drying cycle is used to separate water from the station's atmosphere as the gas is passed through the first stage of the regeneration system. The moisture collected is then passed through filters containing fragmented dolomite, artificial silicates, and salt. The increased water availability has allowed Salyut crews to broaden their food stocks to about 70 items which can be formed into menus that are used in a six-day cycle.

In contrast to previous flights, crews on board Salyut 6 can heat not only food in aluminium tubes, but also canned meats and breads in plastic packs. Ten kinds of dehydrated foods can be prepared with either hot or cold water. This allowed mission planners to increase the crew's intake from 2,900 to 3,200 calories per day.

On 18 July, the cosmonauts carried out repair work and continued reloading their photographic apparatus. In the afternoon, they began a Splav experiment using tellurides of cadmium and mercury. On this occasion the time for regulated cooling differed from that in earlier telluride crystal experiments. Scientists were interested in comparing forms of identical semi-conductors obtained under different conditions of crystallisation.

On 19 July, the crew checked the fuel lines and tanks of Salyut 6 and the Progress, following which, the refuelling operation began. It was performed under the joint supervision of the crew and MCC. After performing various checks, the crew were able to report that the operation had been successfully completed, as had a two-day Splav experiment.

The next day, immediately after breakfast, Kovalyonok and Ivanchenkov prepared their photographic equipment, orientated the Salyut, and then conducted an Earth resources photographic session. During the afternoon, they began another Splav experiment.

As part of the refuelling operation, they checked and prepared the oxidizer lines and tanks. During the course of the day the pumping over of the oxidizer was completed successfully.

On 21 July, the cosmonauts woke at 04.30. Much of the day's work consisted of photography of Byellorussia, the Ukraine, the lower reaches of the Volga, the Caspian, Kazakhstan, Central Asia and the oceans. In the afternoon, the Salyut was placed in a gravitational stabilisation mode, to allow the cosmonauts to carry out another Splav experiment.

Meanwhile, in Warsaw, Pyotr Klimuk and Miroslaw Hermaszewski were decorated with the Grunwald Cross, 1st Class. Zenon Jankowski, back-up to Hermaszewski, was awarded the Commodore Cross of the Order of Poland's Resurgence.

On 22 July, their second rest day, the two men spoke with relatives and friends over the radio, listened to a specially performed concert and watched films on their VTR equipment. At their request, they were allowed to spend part of the day observing the rising and setting of the Sun. They also photographed the Crimea, the Caucasus, the Southern Urals, the lowland coasts of the Caspian Sea, Kazakhstan and the Central Asian Republics. A *Pravda* report stated that the Krystall apparatus, together with its materials, weighed 28 kg (62 lb).

According to Radio Moscow, the crew also switched on the Krystall and used it to make 'films' for computers. In weightlessness such multi-layered film is homogenous. The flight programme provided for 30 experiments of this type.

On 24 July, the crew had yet another day of rest, during which they checked the Salyut's systems and carried out various physical exercises. Further Splav experiments were performed with alloys of aluminium, tin, and Molybdenum. They also continued the previous day's photography.

The Polish Press Agency, PAP, reported that the cosmonauts were continuing a Polish experiment entitled "Test" begun by the Soyuz 30 crew on board Salyut 6. The experiment included psychological and medical research aimed at studying the influence of various factors of space flight on the cosmonauts comfort and efficiency while in orbit.

The Warsaw Military Institute of Aviation Medicine worked out in co-operation with Soviet specialists a special logbook. When making entries, the cosmonauts used a 5-grade scale to indicate space flights influence on their ability to perceive and concentrate, their psychometer activity, memory and so on. The results of "Test" were expected to be of use when planning future manned flights.

On 25 July, the cosmonauts performed extensive medical investigations and experiments, in particular "to study the cosmonauts cardiac activity and also the reaction of blood circulation under measured physical load on the cycle-ergometer." They began these experiments following breakfast and a system check. Kovalyonok then carried out the first medical investigations while Ivanchenkov assisted him, and watched over the instrumentation, as well as maintaining communications with MCC. The pulse rate and blood pressures of both men were normal, and in general, both felt well.

On Earth, Klimuk and Hermaszewski arrived in Wroclaw, the provincial capital of lower Silesia in Poland. At a town hall welcoming ceremony, Hermaszewski was granted the title of honorary citizen. Following a sightseeing tour of Wroclaw, both cosmonauts took part in a ceremony at Hermaszewski's former regiment. They then visited his home town, and held a 'meet-the-people' gathering at the local sports stadium.

On 26 July, the first communications session began at 05.30 when the space complex came within range of the Kosmonaut Vladimir Komarov off the North African coast. The day's programme included routine systems checks, the preparation of equipment for forthcoming experiments, together with Earth observations work. They continued their studies of the Soviet Union and the world oceans. Over 400 pictures had already been taken. They were to be used in

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We have received many complementary letters from readers for our extensive coverage of Salyut/Soyuz/Progress missions. Special thanks are due to the Novosti Press Agency and Panorama DDR/Zentralbild of the German Democratic Republic for photographs and other material used in this series. Ed.

part to study mineral resources in southern Siberia, and in the charting of canals from the Arctic Ocean to the seas in the southern parts of the Soviet Union.

Another Krystall experiment was completed, aimed at obtaining large crystals. The maximum temperature reached in the experiment was 1100°C (2044°F). *Pravda* reported that the pulse rates of Kovalyonok and Ivanchenkov were 68 and 65 respectively, with blood pressures of 120/70 and 125/70. The two men had, it was reported, recently included in their menu green onions which they had grown in space themselves.

Sirena Experiments

At an official ceremony in the Moscow Institute for Space Research of the Soviet Academy of Sciences, Polish scientists were presented with the results of the Sirena 1 and 2 experiments. They were given two capsules, each containing 47 grammes (1.66 oz) of a semi-conducting alloy crystallised by the Soyuz 30 cosmonauts on board Salyut 6 using the Splav 01 furnace. The capsules had been preliminarily examined by the Soviet scientists, who, on the basis of X-ray photographs, stated that the experiment had been a great success, and that a solid crystal had been obtained. Further research would be carried out mainly by two laboratories of the Polish Academy of Sciences' Institute of Physics in Warsaw.

On 27 July, at the request of the Soviet Ministry of Agriculture, the cosmonauts used the MKF-6M camera to photograph an area known as the Salsky experimental zone, in the Rostov region, some 1,000 km (621 miles) south of Moscow. The zone was one of four chosen for practical application of space observation of biological resources. Photographs taken of the area would, it was hoped, become standard photos for recognizing plant species, for determining from outer space the degree of crop ripeness and soil moisture. Space photography has already made it possible to draw up a geobotanical chart of Lake Balkash, to map pasture lands in Turkmenia, and to study the characteristics of irrigation systems in Uzbekistan.

Also during the day, the cosmonauts completed another Krystall experiment, and prepared a capsule containing a semi-conductor crystal for return to Earth. They studied plant growth and the Northern Lights, as well as conducting a full dress rehearsal for the forthcoming EVA, stopping only at the point where the EVA hatch was due to be opened.

On 28 July, the parameters of Salyut 6 were given as 346 x 328 km (215 x 204 miles) x 91 min x 51.6°. On board temperature was 20°C (68°F) and on board pressure was 770 mm on the mercury column.

Kovalyonok and Ivanchenkov conducted Earth observations photography, studying glaciers in the Pamir Mountain, at the request of Soviet glaciologists. They also continued their biological experiments, studying plant growth and sowing new seeds.

On Earth, Klimuk and Hermaszewski were visiting Poznan, in mid-Western Poland, where they laid flowers at the foot of the monument to Yuri Gagarin. They then met young people and visited the astronomical observatory in Poznan. Later, Klimuk, Hermaszewski, Shatalov and Jankowski met with Polish Air Force commanders in Poznan province. They were presented with the "Service for the Air Force" medal, and then went to the town hall to meet the Poznan provincial government.

Extra-Vehicular Activity

On 29 July, the two Salyut 6 cosmonauts carried out an EVA to retrieve the "Medusa" experiment materials located on the exterior of the station. They interrupted their normal sleep cycle to be in voice contact with MCC during pre-depressurization checks. Permission was given to open the hatch in the transfer compartment at 03.57, one minute earlier than planned, as the Salyut passed over Korea toward the Sea of Japan. This allowed about 30 minutes of air to ground communication before egress took place. Almost immediately the spacecraft passed out of ground range, and re-acquisition did not take place for another 1 hour and 07 minutes.

Alexander Ivanchenkov was the first to exit. He swam out of the EVA hatch and immediately secured himself by way of an "Anchor" device located on the station, similar to downhill ski-bindings. "The Anchor's holding firm," he told Kovalyonok, who was filming him using a portable colour camera. The object of the spacewalk was to retrieve a set of biopolymer-sample canisters mounted on the Salyut's exterior, for return to Earth for comparison with samples located inside Salyut. This "Medusa" experiment had been ongoing since the launch of Salyut 6 with the canisters firmly fixed to the exterior.

Alexander Ivanchenkov used special tools to dismantle the materials from the outside of the transfer compartment. The materials included a block containing cassettes with biopolymers and cassettes with polymers, optical and other structural materials used in spacecraft construction. The cosmonauts installed radio-sensitive plates to measure radiation, and inspected the micro-meteorite registration system and reported that no large impact craters were present. There were three panels of samples in all, and these included samples of rubber, plastics, and other sealing materials used in space technology.

At one point, Kovalyonok said: "The Photons are in open space. Alexander Ivanchenkov is working with the scientific equipment which has been here for over 300 days. The samples which were here have been replaced by new ones. Work is drawing to a close. Work in outer space is difficult – but interesting." "If you have finished, then you can return to the spaceship," they were told. Kovalyonok replied, "We would like to take our time. It's the first time for 45 days that we have gone out into the 'street' for a walk!"

The two cosmonauts worked in daylight for about 30 minutes after exiting, and then encountered sunset at approximately 04.25 while over the South Pacific Ocean. Both men then used lamps attached to their spacesuit helmets to enable them to retrieve and replace equipment on the exterior of the station. Both sunrise and ground acquisition occurred at approximately 05.56. The crew returned to the EVA hatch and completed their spacewalk at 06.02 as the Salyut passed over the Pacific. The pulse rates of Kovalyonok and Ivanchenkov during the EVA were 105 and 95 respectively.

Before commencement of the EVA, the station's parameters were given as 346 x 328 km (215 x 204 miles) x 91 min x 51.6°. Viktor Blagov, deputy flight director, said after the EVA that five similar operations were planned for the future, to carry out routine inspections and repairs.

The two cosmonauts had taken a few days to prepare for their spacewalk. First they adjusted their spacesuits to their height, and then checked the functioning of the life-support systems. They then removed some of the equipment from the transfer section, to give them more room to work in.

During the EVA, Georgi Grechko acted as CapCom, a position he was eminently qualified for, having conducted an EVA from Salyut 6 himself, during the Soyuz 26 mission. He later commented "During this latest experiment, Kovalyonok and Ivanchenkov removed research equipment and cassettes with samples of structural materials, and installed a device for registering space radiation."

"In general, the spacewalk had purely scientific purposes, and that is why it is so important. Here is just one example. The cosmonauts removed cassettes with samples of duraluminium, titanium and steel, rubber and glass, ceramic

and other coatings which had been outside the space station for 10 months. While in the vacuum, these materials had been subjected to space radiation, to the action of micrometeroid particles, and to intense heating and cooling. Once they are back on Earth they will be thoroughly studied and are certain to provide new information for the builders of future orbital stations."

He continued: "Usually, when we return from orbit the scientists and engineers shower us with questions. Not infrequently, information on how it feels to be in space is limited only to verbal impressions. This time, however, specialists on materials will get from us 'live samples' which have been tested in outer space. Among them are optical and metal materials, a block of cassettes with biopolymers and radio-sensitive plates to determine the total radiation received by the station. The cosmonauts also have inspected the panels of the micrometeorite recording system. There were no big 'wanderers of the Universe'."

During the rest of the day, the cosmonauts carried out photography "in the interests of science and various branches of the national economy," over Byellorussia, the Ukraine, the Salsk steepes and the Caspian coastal lowlands. On board temperature was 20° C (68°F), and pressure 770 mm on the mercury column.

The cosmonauts also sent this message of greetings to the 11th World Festival of Youth and Students in Havana: "Flying over the heroic island of freedom, we send warm greetings to the finest representatives of the younger generation of the world who have assembled for the 11th World Youth and Student Festival. The aims and tasks of the festival are close and understandable to all of us. They reflect the thoughts and aspirations of all progressive mankind. Dear friends, we wish you fresh success in the struggle for peace and international co-operation and for the freedom and independence of the peoples of the whole world."

On 30 July, the two cosmonauts were given a day of rest, following the previous day's strenuous activities. The crew's doctor reported that they were in good health, and feeling fine. The EVA had had no ill effects on them.

On 31 July, they continued technical and biological experiments, including a Resonance experiment and plant growth studies. They also transferred waste materials to Progress 2, and, using oxygen delivered by Progress 2, raised the air pressure in Salyut to replace the on board atmosphere lost during the EVA and during the Splav experiments.

On 1 August, Kovalyonok and Ivanchenkov continued their biological experiments observing the growth of microscopic plants, onions and other flora. They also studied the behaviour of animals under weightlessness, and conducted photographic sessions over the Soviet Union and other member-countries of the Intercosmos programme.

Krystall Experiment

In addition, they completed their work with Progress 2, and also completed a Krystall experiment. The following is an excerpt from one of the communications sessions:

MCC – "Photons, this is Zarya (Dawn). What are you doing now?"

S6 – "We are busy with the Krystall now."

MCC – "OK, then start inserting the capsule."

S6 – "We have inserted the capsule. Now we are checking the switching of the apparatus. The panel registers 8888, four eights. Everything is OK."

MCC – What is the temperature?"

S6 – "Temperature is now 300-305°C (572-582°F) and continuing to rise."

MCC – "The temperature in the steel containers may fall you understand, but it can be restored and taken to 1100°C (2012°F)."

S6 – "OK. Thanks for the advice. Over and out."

The scientific director of the Krystall experiment, Vladimir Timofeyevich Khryapov, commented on the apparatus. He said, "This is the first time the temperature in an experiment has been taken over 1000°C (1832°F). The distinguishing feature of the Krystall apparatus is that, in the first place, it can operate inside the orbital compartment, without having direct connection with the space vacuum. Secondly, the fact that the apparatus enables technological processes to be conducted by four methods, in distinction from apparatus which were used previously."

"The first method is that of obtaining monocrystals from the gaseous phase by sublimation; the second is obtaining films of monocrystals by the chemical gas-transportation method; the third method is obtaining monocrystals by what is called the moving solvent method to obtain a high-temperature solution; and the fourth, of course, is the traditional method of volumetric-directed crystallization – directed crystallization to obtain volumetric crystals. This is the method used earlier."

On 2 August, at 04.57, Progress 2 undocked, having been linked to Salyut 6 for 23 days 15 hours and 58 minutes The operation was controlled jointly by the cosmonauts and MCC. "Progress 2 has changed over to autonomous flight," said a Soviet report later, "during which individual on board systems and units will be tested. When the test programme is completed, the Progress 2 cargo craft will be slowed down. It will cease to exist on entering the dense layers of the atmosphere."

Also during the day, the cosmonauts observed a volcanic eruption in the ocean, not far from New Zealand. In the evening, they again used one of the furnaces, and, in a TV session, showed off a 12-faceted crystal.

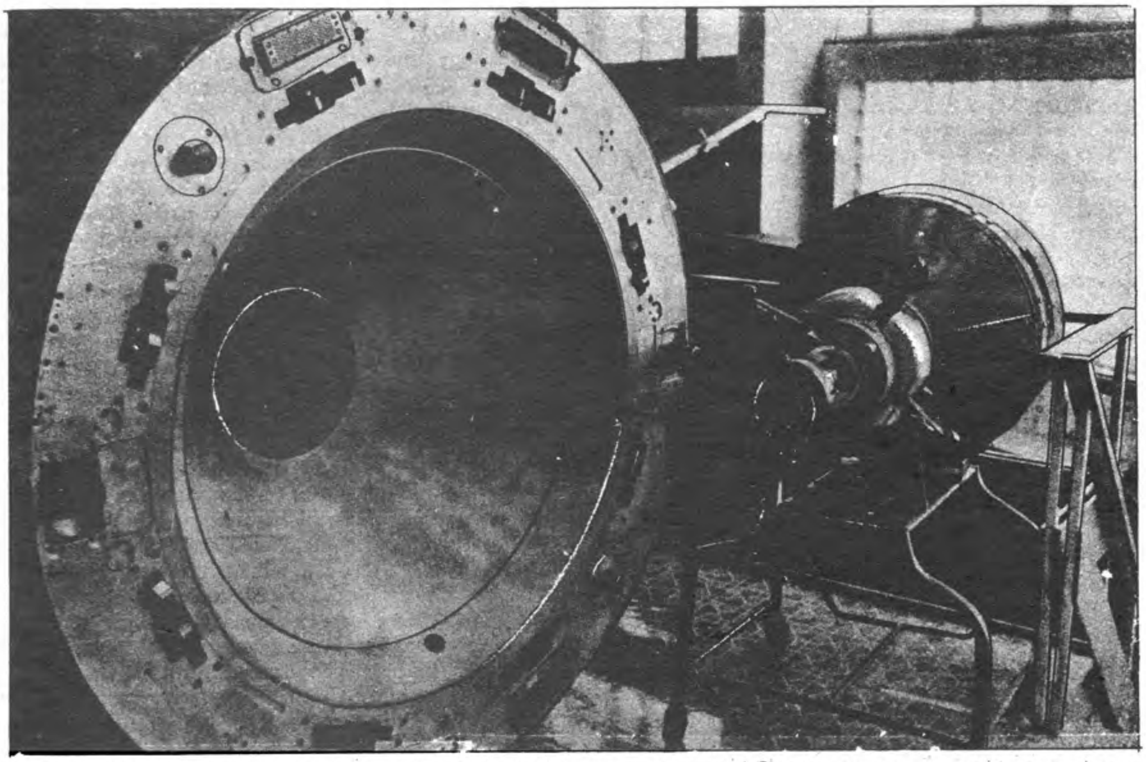
According to Radio Moscow, Soviet cosmonauts had now taken the lead in total elapsed time spent in space, beating the American total of 937 days.

On 3 August, Kovalyonok and Ivanchenkov completed another Krystall experiment, the aim of which was to obtain a germanium monocrystal by the method of directional crystallization.

Tass reported that Progress 2 would soon enter the dense layers of the atmosphere over a pre-determined area of the Pacific. "In the closing stages of its existence, the spacecraft will carry out its final task – to destroy in the atmosphere the waste accumulated in the complex. But, before leaving orbit, Progress 2 will make it possible to test once again the operation of the system of radio rendezvous and orientation, because it is important to accumulate statistical data for the designers."

Physical Training

Tass also reported the text of an article in *Sovetsky Sport* which was about the physical training on board Salyut 6. It said that no work, not even the most urgent, was allowed to interfere with the "space physical training exercises. During one of the days of unloading Progress 2, when they had been moving cumbersome oxygen regenerators, they were tempted to postpone their ride on the veloergometer, the "space-bicycle." "We only have one container left, it won't take us long to tow it out, and that will complete the unloading of the large items. We can make up the physical training another time," said Vladimir Kovalyonok. However, flight director Alexei Yeliseyev gave an immediate categorical refusal. "The labour and rest regime must be



Passive docking port on the engineering mockup of the Salyut space station at the Yuri Gagarin Cosmonauts Training Centre. *Right*, active docking probe of Soyuz ferry.

Panorama DDR/Zentralbild

observed without deviation. Throughout the flight, your physical training must take priority." he said.

The training complex on board Salyut 6, consisting of equipment for running, jumping and other exercises, was known as the KTF (Kompleksny Trenazher Fizichesky – comprehensive physical trainer).

On 4 August, the day was spent on medical checks, including studies of the reaction of the crew to simulated hydrostatic pressure. The results of the medical checks showed that both cosmonauts were fit and maintaining a high capacity for work.

Tass reported that Progress 2 had, after completing its programme, been oriented in space on commands from the Earth. Its engine had been switched on at the time planned, and as a result of braking, the spacecraft had gone into a descent trajectory and entered the dense layers of the atmosphere over the pre-determined area of the Pacific, ending its existence.

On 5 August, a trajectory correction was carried out, following which, the parameters of Salyut 6's orbit were 359 x 328 km (223 x 204 miles) x 91.3 min x 51.6°. The two men spent the day in routine cleaning and health measures, with physical exercises and tidying. They also took a shower, and conducted further experiments with semi-conductor materials.

On 6 August, the crew had a rest day. After breakfast, they had a medical checkup, checked the station's systems, and "of course" did their obligatory daily exercises on the running track and the velo-ergometer. In the evening they made TV reports.

On 7 August, the cosmonauts spent the morning on medical research. Ivanchenkov began a dynamic investigation of the bio-electric activity of the heart, with electrocardiograms being recorded for 24 hours on a new "cardiomonitor" delivered by Progress 2. They also completed a Krystall experiment to obtain an indium antimonide monocrystal. In addition, they carried out maintenance and overhaul work on individual systems, and prepared scientific apparatus for new research.

Progress 3

At 22.31, yet another Progress craft was launched, following closely on the heels of Progress 2. Progress 3 was placed in an initial orbit with the parameters 249 x 195 km (155 x 121 miles) x 88.7 min x 51.6°. According to *Aviation Week and Space Technology*, Progress 3 was launched to achieve orbit about 68 minutes after Salyut 6 had passed over the same area of the Earth. The previous two Progress flights had been launched only about 44 minutes in trail.

All three spacecraft docked with Salyut 6 about 49 hours and 30 minutes elapsed time from launch. This change provides a longer launch window, and more opportunities to launch unmanned resupply missions over a given period of time.

Progress 3 carried cassettes for space processing experiments with alloys and semi conductors, equipment for photography of the Earth and for biological and medical experiments. In addition, the ship carried 280 kg (617 lb) of food, 190 litres (42 gallons) of water, and 450 kg (992 lb) of oxygen.

On 8 August, Kovalyonok carried out a "cardio-monitor" experiment similar to the one performed the previous day by Ivanchenkov. The crew also continued their repair and maintenance work, and photographed the Eastern territory of the Soviet Union, including the Baikal-Amur railway.

On command from MCC, Progress 3 carried out two manoeuvres to increase apogee and perigee. The corrected parameters were 262 x 244 km (163 x 152 miles) x 89.4 min x 51.6°.

On 9 August, Radio Moscow reported that every Progress craft launched to Salyut 6 prolonged the station's life by nearly two months. During the day the cosmonauts carried out on board documentation, physical exercises and systems checks. On board temperature was 20°C (68°F) and pressure 800 mm on the mercury column. At 24.00, Progress 3 docked with Salyut 6, the rendezvous and docking operation having been carried out automatically. Kovalyonok and Ivanchenkov observed the docking from on board Salyut 6.

On 10 August, they began unloading the supply craft after

MCC had opened the docking hatch. MCC recommended a set sequence for unloading the containers, and the cosmonauts reported that they had unloaded containers 6, 27 and 2. These contained letters, newspapers, souvenirs and presents, including a guitar for Ivanchenkov.

Commenting on the new mission, Viktor Blagov, deputy flight director, said "Whereas Progress 1 and 2 were only used to replenish the supplies of the space station, Progress 3 is being used to accumulate considerable stocks of food, water and materials to ensure the functioning of the equipment and to sustain the activity of the crew."

Semi-Conductor Materials

On 11 August, the cosmonauts put the Salyut into a gravitation-stabilised mode to carry out materials processing experiments. Using the Splav furnace, they obtained semi-conductor materials – monocrystals of a solid solution of tin, lead and tellurium, fine layers of sulphides and selenides of cadmium and zinc, and an aluminium-bismuth alloy. also used the Krystall furnace to obtain crystals of gallium arsenide.

On 12 August, the cosmonauts completed the Krystall experiment in the morning, and the Splav experiment in the afternoon. During the day, they tidied the station, checked the systems, did physical exercises, and sent a message of greetings to Soviet builders on the occasion of their festival.

On 13 August, the cosmonauts had a day of rest. They performed their usual physical exercises and systems checks, together with TV reports. During one communications session, they described what they could see of the Soviet Union, particularly progress with the harvest. They had to break off their report when clouds obscured the area.

On 14 August, Kovalyonok and Ivanchenkov resumed the unloading of Progress 3, which they described as a difficult operation, as everything had to be fastened down. They completed a Krystall experiment, and continued a Splav experiment. *Tass* reported that the experiments carried out in the previous few days had included a Polish Sirena experiment in the Krystall furnace.

On 15 August, the cosmonauts continued unloading operations. In a communications session, they referred to crystals that were coloured black to golden, and flat-shaped. This type of crystal would be mainly used in laser TV – a cadmium compound crystal could, when illuminated by an electronic ray, produce a light red image.

On 16 August Kovalyonok and Ivanchenkov conducted medical checks and investigations, particularly into the cardio-vascular systems reaction to graduated exercise on the velo-ergometer. They used the Polinom-2M, Rheograph and Beta apparatus to record and monitor the results. The day's programme included an experiment to study changes in the composition of the gas medium inside the complex and continued experiments with the Splav and Krystall. Both men were reported to be feeling well.

On 17 August, a Krystall experiment with semi-conductors of sulphide and silicon compounds were completed. The engine of Progress 3 was used to carry out a trajectory correction, following which the orbit of Salyut 6 was 359 x 343 km (223 x 213 miles) x 91.4 min x 51.6°.

On 18 August, further materials processing experiments were conducted, together with biological experiments with onions and other plants. On 19 August the cosmonauts completed the unloading of Progress 3, tidied the station, did physical exercises and carried out systems checks. They also continued their Earth observations work and experiments with the Krystall furnace.

On 20 August, the two men had a day of rest. They were said to be in good health. During the day, they photographed the Earth, and "outstanding phenomena." All systems were working normally.

The following day, Progress 3 undocked from Salyut 6, after a joint flight of only 12 days. The undocking operation was controlled jointly by the cosmonauts and MCC. Progress 3 was to be put through the usual tests whilst in automatic flight before re-entry.

On 22 August, the crew performed medical check-ups and Earth resources photography. In the evening, another smelting experiment was conducted. According to Radio Moscow, they had already carried out 20 such operations.

On 23 August, the first communications session of the day began at 06.00 when the Salyut entered the radio zone of the *Akademic Sergei Korolyov* situated in the Atlantic. During the day the men checked the on board equipment of Salyut 6, and replaced units nearing the end of their planned lifetime with new equipment delivered by Progress 3. Physical exercises followed.

On 24 August, Progress 3 was commanded to re-enter the Earth's atmosphere. The cosmonauts conducted Earth observations photography and comprehensive medical checks, as well as further studies of plant growth. They also completed another Krystall experiment.

On 25 August, they continued the Earth observations work, although most of the day was spent on cleaning and health measures. The on board parameters were 21°C (70°F) and 810 mm pressure.

A new experiment to produce a semi-conducting material in the on board furnace was conducted. Radio Moscow reported that the total output from the Splav and Krystall furnaces had now equalled the output of a ground plant over a whole year.

In an interview on Radio Moscow, Dr. Anatoli Yegorov said that all cosmonauts were trained quite thoroughly in first aid. They were capable of bandaging an injury, giving an injection, taking blood samples, and even treating toothache.

On 26 August, the cosmonauts were given a day of rest – which started with a systems check followed by physical exercises and a communications session.

At 14.51, the Soyuz 31 spacecraft was launched, carrying into orbit the first East German cosmonaut.

Errata

In "Missions to Salyut 6," Part 3, *Spaceflight*, November 1978, p. 373, it was stated that the calculated time for the touchdown of Soyuz 26 was approximately 11.46. However, I am informed by Ralph Gibbons that upon checking his calculations, a more accurate figure for touchdown would be 11.24, (which has also been confirmed by another source). Consequently, the undocking time should be amended to read as approximately 08.05 on the 16 January 1978.

Acknowledgements

The author wishes to thank the following references: *Novosti Press Agency, Soviet News, Soviet Weekly, Moscow News, Moscow News Information,* Radio Moscow, *Flight International,* and *Aviation Week and Space Technology.* Special thanks are due to Ralph Gibbons, Phillip S. Clark, and Michael J. Richardson for their valuable assistance in compiling this article.

[To be continued

NEXT MONTH

Contrary to a popular view, British space activity is significant in many ways and continues to stimulate science and industry. In the June issue of *Spaceflight* Peter Conchie reviews the field and gives his conclusions. Other articles in this issue will include "Manned Manoeuvring Unit" by Dave Dooling and "Four-Planet Meteorology" contrasting weather conditions on Venus, Earth, Mars and Jupiter.

SPACE MEMORABILIA

By L. J. Carter

Introduction

Space souvenirs can be loosely divided into two classes, i.e. those *related* to the event, directly or indirectly, if only in date, and those so remote that they have really no connection at all. Items with a direct connection, e.g. souvenirs of the actual event such as autographs, original notebooks, drawings, photographs, etc., add a good touch of "authenticity" to a collection, especially if accompanied by suitable descriptive matter. Even newspapers published *at the time* give the air of direct participation, though magazine articles tend to be less so.

When it comes to *what* to collect, the requirements depend on such things as interest, what is available or most convenient to collect, cost, etc., escalating from a general collection to the more discerning – or even more fanatical – as one moves on. A good deal depends on storage space so largish items are not much sought after, whereas the Doctorate of Divinity, or even Sainthoods, sold recently by an American Church, require no space at all and have the added advantage, no doubt, that they are exceptions to the old rule that "You can't take it with you!"

Even so, they illustrate that it is the unusual which many people may wish to seek.

Sometimes, when a collection gets out of hand, something has to give. Often the entire collection is junked, though one member interested in press cuttings which he filed in specially-made books, reached such an extreme that he had to have a special extension built onto his house, simply to accommodate the great pile of cuttings books. This illustrates another problem, that of building up a collection too quickly. In the case of press cuttings, the collection was expanded by subscribing to Press Cuttings Agencies, which led to the discovery that much of the material not only duplicated and triplicated itself *ad nauseum* but greatly diluted the interest in the collection.

All or Part?

Two further questions which arise in rapid succession are:-

(a) Whether the collection is *finite*, e.g. the first-day covers to record the flight by Glenn, or almost infinite, say space stamps generally.

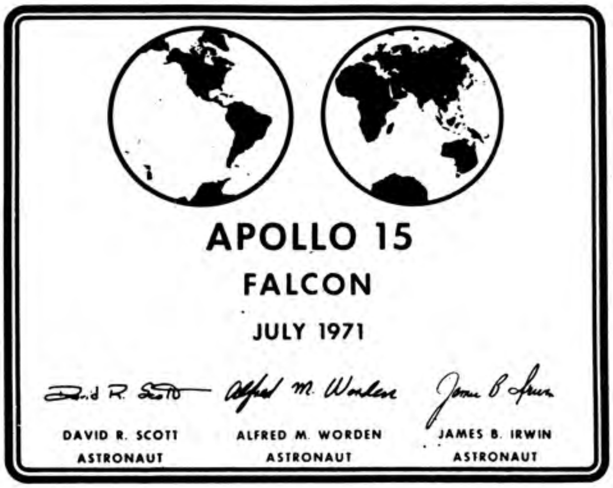
(b) *Storage requirements.* For example, newspapers are easy to acquire, and cheap, but take up much space, collect dust, present retrieval problems after a while and also tend to deteriorate rather quickly.

This leads on to the question of presentation. Collections need to be admired, both by the owner and his friends. The Esso space medallions, for example, were finite, i.e. they made up a set which could be easily mounted and presented. Soviet space badges, on the other hand, possess long pins and have to be presented with care. Only so many can go on one's lapel; the rest go in a box and subsequent display is very difficult. The same applies to most coloured tin badges, even those with shorter pins, for they are usually too bulky to mount satisfactorily. Cloth badges, on the other hand, such as those for the Mercury, Gemini, Apollo and other flights, present few problems: they can easily be framed or placed in suitable albums.

The Need for Personal Identification

The interest of any collection is greatly enhanced where there is a "story" to go with each item, particularly if this can be related in some way, even tenuously, to the collector.

A perfect example of a "story" appeared in the pre-war rocket stamp collection of Mr. R.A. Huber. Press cuttings, notes, photographs, signatures – in fact any souvenir around – was pressed into service to buttress the stamps.



Apollo 15 plaque of the kind purchased at the Kennedy Space Center, Florida.

Although extra work is involved, each collector ought to provide some written record, adjacent to each item saying:-

(a) How it came into his possession;

(b) Where and from whom;

(c) The date;

(d) Its previous history, circumstances, cost, etc.

One can easily see this if we compare it, say, with the example of an old coin collection. The interest is greatly improved where details of the date of discovery, by whom, where, etc., including a reference to a detailed archaeological report, are added, along with photographs and the like.

Some Pitfalls and Suggestions

What to Collect

Not too long ago it was easy to collect space souvenirs freely. Now, one needs to decide whether one wishes to buy or go to some trouble to collect things not generally for sale, i.e. whether one wants the easily available or the more unusual.

I kept a more unusual collection myself once. It consisted of queer letters received over the years. I called it the "Crazy File". The Council, at that time, got to learn of it and decided that an article on its contents would interest other members. They asked a member to prepare such an article, but here a mishap occurred: the prospective author found several letters from himself in the collection!

Software

The biggest demand is for specially-made souvenirs, though whenever I see such collections I always look for, but rarely find that it includes the minor items, i.e. the software of history, the things so much taken for granted that no one ever keeps any of them, so they are rarely preserved anywhere. Examples are boxes, wrapping papers, programmes, tickets giving directions and the like.

A good example of this appeared in the wartime German film entitled "History of Rocket Development" which was

screened before the Society several years ago. It included, incidentally, examples of the headed letter-paper used by the then active space societies, our own BIS letter-paper appearing among them and depicting a motif of a rocket flying above the lunar surface!

Other examples are space-orientated advertisements. Some years ago *JBIS* recorded the first appearance of these, so the time-scale is still quite short. Basically, they can form a most interesting and attractive collection. Prints can be taken from magazines or even obtained, sometimes, with cardboard cut-outs, from the original advertisers, because the advertisements one actually sees are usually only one part of a campaign, with numerous other types and samples available based on the main theme. I made such an enquiry with a well-known firm of brewers some years ago and received back a heap of specimens, including a bottle of beer made up into the form of a rocket! Sometimes, one can add to this by taking one's own photographs of advertisements, either alone or in curious juxtaposition with others, or having some connection which provides a more personal or interesting illustration.

An advantage is that this sort of material is enormously varied, invariably brightly-coloured and usually very cleverly done.

Requiring less effort to attain would be a collection of space-orientated birthday and Christmas cards*. If one has friends abroad, a little prompting might add substantially to the flow, for here, again, mounting is easy and the presentation can be made to look extremely attractive and likely to be of interest to all comers. For best results, the envelopes should also be retained and mounted behind each card.

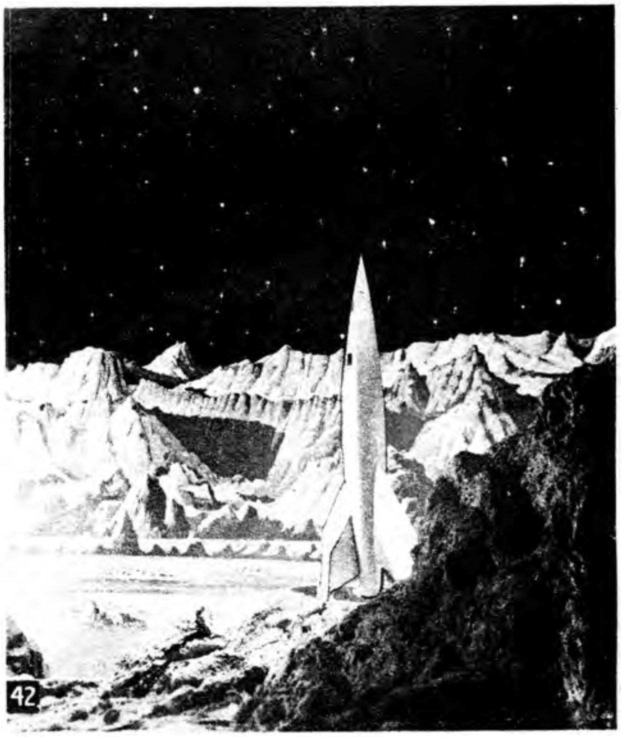
More tricky to obtain, but much more likely to be unusual, would be a collection of space posters. Considerable enterprise may be required. If I can give a comparable example, let us take, say, trams! How would one collect posters of trams when there aren't many trams around? Well, some are issued by museums each year, others can be obtained as reproductions from pre-war posters, and perhaps the flow could be expanded by getting posters from abroad, where they *do* have trams!

In the case of space posters one would need to keep an eye open for details of international space meetings and congresses around the world. To some extent it would be a "lucky dip" but quite surprising new material might result. For example, during the 29th IAF Congress, a large coloured poster was issued free of charge to all the participants which was basically a satellite picture of Yugoslavia, quite an attractive item in itself.

Cards come in all shapes and sizes. Postcards are relatively easy to obtain but there are many other variations. One example might be the series of cigarette cards issued by Wills in 1928 called "Romance of the Heavens" and which, suitably framed, would be good enough to grace any living room. Latter day examples are those issued by Brooke Bond and, slightly larger, by Weetabix. Quite by chance I was given the originals of some of the early Weetabix set, at least twenty years old now, and which were about to be scrapped. I had, in fact, originated the set myself though I cannot now recall the cooperating artist, date of issue, numbers issued or any of the other essential data which a true collector ought to possess.

Models

When it comes to artifacts, the scope is legion and would



'Still' from the George Pal film, *Destination Moon*, which appeared on a BIS Christmas Card of the 1950's and also re-used for a Society film strip – hence the number "42" in the lower left corner.

probably justify putting a display on a shelf, in a china cabinet, or in some other pride of place.

The first which occurred to me are the little figures put out by Kellogs Corn Flakes which I designed for them, but so long ago now that the date escapes me. I was required to design six spacemen in all, each undertaking a different task. This was long before there was any such thing as a lunar programme. I worked out five poses, but stumbled over the sixth, and eventually botched it up with an imaginary long-handled tool of a completely imaginary shape.

Imagine my astonishment when I found these exact figures, but larger, on sale at NASA Houston during the Apollo flights, and identical in every detail, even including the mysterious tool! I was even more surprised when a friend picked up the appropriate figure, stared at it for a moment, and then replied solemnly that the sixth astronaut, was in fact, holding the scoop! (This was the most important emergency tool on Apollo: the aim was – should the mission look tricky on arrival – to scoop up some of the loose dust and return to Earth hot-foot!).

Many members already collect space models, mainly in the plastic kit form. These, however, suffer from extreme fragility and, possibly, might be worth even more in later years if they were not assembled at all but retained in their original boxes and packaging! On this level was a plastic "Paint yourself a Lunar Landscape" which I also helped to design!

I would advocate a collection of the more solid toys, not the "mechanical man" type of toy, but those which, more or less, faithfully represent the state of the space art at any particular time. I was particularly intrigued the other day to see a model rocket, issued in the 1930's. It was a solidly made job, complete with flashing "exhaust" as it moved along. In the nose was a stewardess dishing out drinks to the passengers but, and most interesting, the design of the rocket showed that the great bulk of it had been taken up by the

* *At one time the Society produced Christmas cards for sale to members, depicting a scene from "Destination Moon". Unfortunately, cost ruled out coloured cards and handling charges also supervened to prevent continuance of the project. The same criteria, but with even more emphasis, applied to the Society's one-time Calendars.*

SOCIETY NEWS

COUNCIL NOMINATIONS

Nominations are invited for the Council Elections to be reported to the 34th Annual General Meeting which will be held on 13 September 1979.

In response to suggestions that more information about each Candidate should be provided, a revised Nomination Form has been prepared for use this year. Copies are available on request to the Executive Secretary, enclosing a foolscap reply-paid envelope.

Each Candidate accepting Nomination will need to sign the Form and must be proposed and seconded by other members whose signatures should also appear.

The last date for the receipt of Nomination is 21 June 1979.

If the number of Nominations exceeds the number of vacancies, Ballot Papers will then be prepared and circulated to all members as soon as possible to enable voting to take place.

IMAGE PROCESSING TECHNIQUES

The Third BIS Conference on Computers and Space Technology will be held at the SRC Appleton Laboratory, Slough, Bucks., on 15-16 November 1979.

The theme will be *"Image Processing Techniques Applied to Astronomy and Space Research"* with particular emphasis on the following aspects:-

a) Astronomical Image Processing

b) Planetary Imaging

c) Remote Sensing

d) Interactive Processing and System Design

e) Applications of Array Processors

f) Image Restoration

Offers of papers, including a 300-500 abstract, should be sent, as soon as possible, to the BIS Executive Secretary, Mr. L. J. Carter, The British Interplanetary Society, 12 Bessborough Gardens, London SW1V 2JJ. (After 1st May the address will be 27/29 South Lambeth Road, London, SW8 1SZ.)

Enquiries related to the Conference programme should be sent to the Conference Chairman, Dr. R. Holdaway, Science Research Council, Appleton Laboratory, Ditton Park, Slough, S13 9JX, England.

DAEDALUS BLUEPRINTS

The Society is offering for sale a limited number of sets of "blueprints" of the starship designed by the Project Daedalus Study Group.

The three vehicle drawings concerned are the geometry of the complete vehicle (Drawing D-001) shown on page S106 of the Project Daedalus final report, the vehicle first stage configuration (D-002) on page S93, and the vehicle second stage configuration (D-003) on page S94.

These are the most detailed Daedalus drawings in existence. Two (D-002 and D-003) will be supplied in A3 size i.e. approximately 33" x 24" or 85 cm x 60 cm, and D-001 at 22" x 19" or 56 cm x 48 cm. They will be ideal for display purposes, or as a guide to model making.

The blueprints are available, at a price of £2.00 ($4.00) post free for the set of three drawings, from the Executive Secretary, British Interplanetary Society, 12 Bessborough Gardens, London SW1V 2JJ. (After 1st May the address will be 27/29 South Lambeth Road, London, SW8 1SZ.)

PROJECT ORBITER: A BRITISH CONNECTION

On 31 January last the United States celebrated the 21st anniversary of the launching of Explorer 1, the first American satellite. It is little known that this project sprang from a research effort by the U.S. Office of Naval Research (ONR) under Project Orbiter, the full history of which has yet to be written. In the following letter, for the first time, the former chief Engineer (Air Branch) ONR acknowledges that a study carried out for the British Interplanetary Society between 1948-51 into "minimum satellite vehicles" played a significant role. The extract in the letter referring to the initiation of Soviet satellite work (which Project Orbiter pre-dated) is taken from *Pravda* of 7 December 1977.

Gentlemen, I have been planning for some time to write to you concerning your excellent paper, "Minimum Satellite Vehicles." in the book "The Artificial Satellite," London, 1951 – Proceedings of the Second International Congress on Astronautics.

May I inform you that this paper was used by me during 1952/54 to direct the first United States Space Project at the Office of Naval Research in Washington, D.C., where I was Chief Engineer of the Air Branch, to an immediate application with available hardware in the United States.

I saw Mr. A. C. Clarke on 25 November 1952 at his home – 88 Nightingale Road, Bounds Green, London. Mr. Clarke told me of your report, which I obtained the following day. When I analyzed your data I immediately saw that we could make a three-stage rocket with a very small orbiting payload, using hardware available to us at Office of Naval Research. This eventually became ONR Project "Orbiter" and was launched as "Explorer 1." in January 1958.

A recent Russian article, "Start into Space" – NEW TIMES, No. 40-77 by V. Gubarev, states: "In 1955 the Presidium of the USSR Academy of Sciences requested comments on the use of artificial Earth satellites." In 1954 Sergei Korolyov had written that "It would be timely at this present moment to organise a research division to pioneer a satellite." President Eisenhower announced in July 1955 the ONR Project. We could have launched it in 1956, but Project "Vanguard" temporarily replaced "Orbiter" for political reasons.

I had been working at ONR since 1949 on Space Program studies, and I gave the first U.S. Space contract to Aerojet in 1952. "'Sputnik' was just a ball from which the antennae of a transmitter jutted out. It carried nothing *of the scientific instruments, the sundry sensors, traps and other gadgets that extra-terrestrial labs carry into Space now-a-days."*

Thanks to your report, I proceeded to a three-stage rocket.

ALEXANDER SATIN,
California, U.S.A.

The paper "Minimum Satellite Vehicles" by K. W. Gatland, A. M. Kunesch and A. E. Dixon first appeard in "JBIS", **10, 6,** November 1951, pp. 287-294.

CONTRIBUTING TO 'SPACEFLIGHT'

Few readers, apart from Members of the Council and the small team directly involved, probably appreciate the enormous flow of material which has to be obtained and processed to fill the 48-page issues of *Spaceflight* every month. The work involved in the magazine, which includes very little space for advertising, amounts virtually to putting together an encyclopaedia each year – without the benefit of the large staff and facilities which a commercial publication would enjoy. Very little advertising revenue is received for *Spaceflight* whereas such income is the main support of many publications. We would therefore urge members to remember *Spaceflight* when opportunities arise for them to put such business our way. Advertising rates are available on request.

We have always relied heavily on our members and friends throughout the world to contribute articles to *Spaceflight*, and the larger issues now invite an even greater response.

This is why we have a pressing need for crisply-written material on every aspect of space developments.

We need to know how space science and technology are developing abroad, in such countries as India, Japan and Argentina, as well as the United States and the Soviet Union. We are particularly interested in Third World applications, such as Earth resources observations, domestic communications satellites systems and direct-broadcast education programmes.

We are seeking material on subject areas over the entire spectrum of astronautics, from launch vehicles, satellites and spacecraft to bi-medical studies.

We are interested in new advances in space physics and astronomy, keen to roll back the frontiers of interplanetary flight, to examine new ideas for the exploration of the Solar System and to expand our discussions of the problems of SETI – the Search for Extra-Terrestrial Intelligence – and all other aspects of interstellar flight.

We wish to feature the latest developments in micro-electronics related to space research, to bring to light new space-related products and to enlarge our coverage of future applications – such topics as satellite solar power stations, the industrialisation of space and space colonies.

We are also keen to discuss the social and political implications of mankind's expansion into space.

All of these are areas in which members and others could express themselves through our pages. We need short-to-medium length articles (2,000 to 4,000 words) illustrated with half-tone and/or line drawings – throwing light on new developments. We also have room for short Reports, Reviews and Correspondence: shorter items, acknowledged to the author, are normally included in our regular Space Report feature.

Illustrations are becoming another vital part of our publication. We *must* have a regular supply of up-to-date photographs and illustrations of all kinds to embellish our pages.

The only stipulation we make is that, for reasons of economy, we would much prefer line drawings to be either drawn or reduced to the sizes of 82 mm, 142 mm or 178 mm wide, for this helps us materially in preparing layout.

Our aims are twofold: to help fill the constant need for the exchange of information between those seeking to advance science and technology of space flight and the need to bring knowledge of the benefits of astronautics to a much wider public.

Will you, through our pages, help to promote and forge these links more strongly?

Early publication is offered, subject to the normal procedure of review by our Editorial Board.

If you would like to prepare material for publication, or know of someone else who might wish to do so, please write in the first instance to Mr. L. J. Carter, Executive Secretary, The British Interplanetary Society, 12 Bessborough Gardens, London, SW1V 2JJ. After 1 May the address of the Society will be: 27/29 South Lambeth Road, London, SW8 1SZ.

WELL DONE!

The Development Appeal took another boost when Douglas Arnold went to Decorum College of Further Education in Hemel Hempstead to give a talk on space exploration, for this inspired our President, who lives in Hemel Hempstead, Professor G. V. Groves and his wife to turn up at the College complete with new and back issues of *Spaceflight*, plus a special booklet donated by Mr. Arnold, thus leading to a very good "selling" area eagerly sought after by the 200 or so audience.

As a result, no less than £33.00 was raised to help swell the Society's funds, not counting the possibility of new members joining as a result of the forms which were freely handed out.

LAPEL BADGES

As the stock of old-style Society lapel badges is now rapidly coming to an end, arrangements have been made for the badge to be updated, with the new Logo, identical to the one which appears on the front cover of *Spaceflight*, inserted instead. The new badges will all be of brooch type, as formerly.

Many years have elapsed since the current badges were first supplied so the cost of these to members has remained constant, and very low, for some time. Unfortunately, production costs have more than doubled in the interval with the result that the selling price of the new badges has to be increased accordingly to £1 ($2.00) each.

We are advised that there is a production delay of three months in preparing new dyes and executing new orders, so members ordering badges should be prepared for this.

BIS COMMITTEES

Introduction

As part of the BIS Development Programme the Council has recently undertaken a review of its committee structure. The intention is to increase and usefully harness the support that is available to the Society through its membership. As members already know an important step is now being taken with the move of our Offices to a new headquarters building containing a meetings room, library and much needed working space. It is therefore appropriate that a committee, the *Facilities* committee, should be set up to be responsible to Council for the whole range of operations that concern the new building, its use and maintenance.

The *Facilities* Committee is the only committee to be set up in an essentially new administrative area, but a number of previous *ad hoc* Working Groups have been raised to committee status with the formation of the *Education, Public Relations, Space Technology and International Liaison* Committees. The already existing *Programme, Publications, Membership* and *Executive* Committees continue to operate in their traditional roles apart from slight changes to avoid overlap with the new committees. The above committees report directly to Council, as do BIS *Branch* Committees.

BIS Committees are, essentially, *Working* Groups. They have both routine commitments and specific tasks to complete and rely heavily on the efforts of committee members and others to see that these are carried through. The Reports of each Committee are reviewed regularly by the Council with an overall annual review of targets and achievements to determine any steps necessary to increase their effectiveness.

Alan I. Lewis

ALAN I. LEWIS *(Chairman, Facilities Committee) is Group Estates Director, Combined English Stores Management Services Limited. He is a Fellow of the Royal Institution of Chartered Surveyors and a Freeman of the City of London.*

Facilities Committee

This committee's responsibilities are for the fabric of the Society's building and its contents, the use of the premises, including its frontage and yard, and for ensuring orderly conduct, safety and security at all times. The Committee Chairman is Alan I. Lewis, the Society's Hon. Surveyor who has already provided substantial help and advice to the Society during all stages of the planning and construction of the building.

In its work the Committee needs to call upon a wide range of experience, and the help of members in the technical trades, legal profession, etc., may be sought as specialist advisers as particular problems arise.

Chairman: A. I. Lewis

Vice-Chairman: G. J. N. Smith

Members:

Dr. E. J. S. Becklake	A. T. Lawton
P. R. Freshwater	Dr. W. R. Maxwell
Dr. M. D. Jones	G. V. E. Thompson
Ms. S. A. Jones	M. W. Wholey

Secretary: L. J. Carter

Education Committee

The work of the earlier BIS Education Working Group earned considerable renown with their preparation of three books for teachers, i.e. *A Handbook of Astronautics, Mathematical Problems in Astronautics* and *Physics Problems in Astronautics* and a variety of film strips, wallcharts and booklets for students, besides two other volumes for more advanced studies. Under the BIS Development Programme the preparation of astronautics material for all levels of learning is to be continued and extended as far as resources will permit. The continuing nature of this work is determined by new advances in space research and technology, the areas of investigation that they open up and the needs and interests of new generations of students. In detail, this Committee is responsible for Space Study Courses and other relevant courses and meetings, careers advice, promotion of material for the Science and Education issues of *JBIS*, and for material specifically oriented towards schools. From time to time educational material is included in *Spaceflight* as an eight-page centre piece. The Committee Chairman Gordon J. N. Smith is keen to see increasing cooperation between industry and educational institutions in the space field. Together with Peter J. Conchie he is currently editing a new series of *JBIS* issues appearing in 1979 on science and educational aspects of space developments.

Chairman: G. J. N. Smith

Vice-Chairman: P. J. Conchie

Members:

M. F. Allward	Prof. G. V. Groves
Dr. E. J. S. Becklake	K. S. Page
S. Buchanan	G. E. Perry
Dr. S. W. H. Cowley	M. Stenhoff
R. F. Gibbons	P. J. Tortise
J. C. Gilbert	G. M. Webb

Secretary: A. D. Farmer

Public Relations Committee

The terms of reference given to this Committee are to prepare and issue publicity and press material; to deal with media enquiries; and to review procedures and submit recommendations for making information about the Society more widely known. Such activities have been very effect-

Left: Peter J. Conchie

Right: Gordon R. Smith

PETER J. CONCHIE *(Chairman, Education Committee) joined the B.I.S. in 1962 shortly after he became involved in the Europa launch vehicle programme. In 1964 he was responsible at Hawker Siddeley Dynamics for the Assembly, Integration, Test and Launch campaign for the satellite ESRO 2. He was Project Manager for ESRO 4 and has been closely associated with the successful outcome of the Orbital Test Satellite and Marots programmes. A major part of his effort in recent years,at British Aerospace Corporation, has been to apply expertise acquired from the OTS-ECS programme to be applied to the sale of satellite communications systems for the Third World. Mr. Conchie is editor of the "JBIS" Communications Issue and was responsible for the recent one day meeting on the European Communications Satellite programme. He represented the Society at the 1976 I.A.F. Congress where he also gave a paper on the ECS programme.*

GORDON J. SMITH *(Vice-Chairman, Facilities Committee) worked at British Aircraft Corporation, Bristol on Aerodynamics, performance and control of guided weapons for five years before joining Space Division, Hawker Siddeley Dynamics, Stevenage about 15 years ago. He was appointed Assistant Chief Dynamics Engineer in 1968 since when he has worked on many projects and studies, mainly for ELDO, ESRO, ESA and the Ministry of Defence. These have included ELDO and Ariane Launch Vehicles; ESRO Satellites; Space Tug; Regional Derivatives of OTS/ECS, and Shuttle Applications. Recently, Mr. Smith transferred to British Aerospace Dynamics Group at Bristol following appointment as a Project Manager of military space systems.*

ively handled over many years by Kenneth W. Gatland and Len J. Carter, who have been well placed to do so being respectively the editor and assistant editor of *Spaceflight*, together with the assistance of other members when specialist information was needed. The activities that fall within the province of this Committee can be very time-consuming, particularly when requests for information arise, and often need to be undertaken at short notice. Other members with practical experience of public relations who feel that they could further the Committee's work should forward their name and details of the ways in which they might be able to help to the Executive Secretary.

Chairman: K. W. Gatland

Members:

L. J. Carter G. V. E. Thompson Dr. A. R. Martin

Secretary: A. D. Farmer

Space Technology

The terms of reference of this Committee are to discuss the broader aspects of Space Technology and to evaluate courses of action for submission to Council on matters of technical policy; to initiate proposals for specific projects; and to organise technical symposia on appropriate topics. This last activity the Committee takes over from the *Programme* Committee, while its other responsibilities are similar to those handled in earlier years by the Society's *Technical Studies* Committee. Its Chairman is Peter J. Conchie who is Technical Manager of the Infra-Red Division at British Aerospace, Stevenage.

Chairman: P. J. Conchie

Members:

S. R. Dauncey
Dr. L. Davies
A. D. Farmer
C. H. Martin
J. A. Parfitt
G. R. Ramsden
G. R. Richards
L. R. Shepherd
A. L. Stimson
C. R. Turner

Secretary: G. M. Webb

Programme Committee

This Committee is responsible for organising film shows and lectures, visits and exhibitions in the London area and elsewhere. Now that its former responsibility for technical symposia is being undertaken by the *Space Technology* Committee, more time is being given to examining the possible range of meetings that may be scheduled and to the publication of reports of meetings. Any person in a position to give a lecture on a selected topic or a short talk as part of a more general programme is invited to contact the Society. The work of this Committee depends on a continual inflow of new information and ideas from members on topics and events that are likely to attract good audiences.

Dr. L. R. Shepherd

Alan D. Farmer

DR. L. R. SHEPHERD *(Chairman, International Liaison Committee), a nuclear scientist, was an original member of the team which originated the concept of the High Temperature Gas-Cooled Reactor (HTR). Between 1959 and 1976 he worked in the DRAGON PROJECT, at AEE, Winfrith, Dorset, an international programme in which 13 European countries participated. The Project designed, constructed and operated the world's first ETR. He was Head of research and development for the first eight years of the Project and from 1968 to its termination was Chief Executive. Dr. Shepherd joined the B.I.S. in 1935. Some of his Space interests and activities are listed below:*

1946-1977	*Member of B.I.S. Council*
1953-1956) *1957-1959)*	*Chairman of B.I.S. Coumcil*
1959-1960	*President of B.I.S.*
1956-1957	*President of the I.A.F.*
1958-1961	*Member of the Propulsion Committee of the Aeronautical Research Council (ARC).*
1959-1962	*Member of the British National Council on Space Research.*
1962	*President of the I.A.F.*
1963-1974	*Member of the Aeronautics Committee of the ARC.*
1968-1971	*Chairman of the Astronautics Committee of the ARC.*

ALAN D. FARMER *(Member, Space Technology Committee/ Secretary of others) is Applications Consultant Manager of Tymshare UK City Branch responsible for managing six 'front-line' computer services support staff. TUK City Branch is responsible within TUK for the Unilever group, and all City and Financial Customers. In 1972-73 Mr. Farmer worked at BAC, Bristol, on satellite systems and in 1973-75 did research work at University College London. He helped prepare for rocket campaigns and represented the college at some SRC and liaison meetings. His work included a 24-hour synoptic launchings at Wallops Island, Virginia and data analysis of several launchings. Mr. Farmer has been seconded to various committees as Acting Assistant Secretary with a view to becoming a full time employee with the Society when our new offices are fully operational. His duties will also include the preparation of material from meetings for publication.*

Chairman: Prof. G. V. Groves

Members:

J. R. Adams	A. T. Lawton
E. B. Dove	K. C. Pike
M. R. Fry	F. G. Pearce
Capt. C. R. Hume	V. J. Read
A. Kenden	I. R. Stott

Secretary: L. J. Carter

Publications Committee

This Committee is responsible for the production of the *JBIS* and *Spaceflight* issues each month, as well as the preparation and publication of other material as delegated by the Council. Behind this short description lies the great effort which goes into consultation, planning and execution, of ironing out the practical problems of maintaining a regular publishing schedule, securing a continuous inflow of suitable material, and improving the standards of BIS publications. In addition to the Committee's own members, who are usually deeply involved in either the editorial or the production side of the work, the Committee relies extensively on the help of reviewers and specialist editors to make up the team effort that is necessary to carry through these quite significant tasks.

Chairman: A. T. Lawton

Vice-Chairman: Dr. W. R. Maxwell

Members:

K. W. Gatland	Ms. S. A. Jones
Prof. G. V. Groves	Dr. A. R. Martin
D. M. Holmes	G. V. E. Thompson
L. J. Carter	

Secretary: A. D. Farmer

International Liaison Committee

This Committee continues the work of the Society's former IAF Committee but with enlarged responsibilities for all international matters. It is required to deal with matters concerning Society relations with other organisations overseas, including the nomination of Society representatives to serve on international bodies and the examination of UK

matters which have overseas aspects. Its Chairman Dr. L. R. Shepherd is a past-President of our Society and also of the International Astronautical Federation.

Chairman: Dr. L. R. Shepherd

Vice-Chairman: Prof. G. V. Groves

Members:

Dr. E. J. S. Becklake	G. J. N. Smith
P. J. Conchie	A. L. Stimson
K. W. Gatland	G. V. E. Thompson
C. E. S. Horsford	C. R. Turner

Secretary: L. J. Carter

Membership Committee

Traditionally this Committee has a twofold role, namely that of dealing with applications for admission to Membership and of actively promoting membership applications through the preparation and distribution of membership material. As repeatedly emphasised, an important objective of the BIS Development Programme is to increase membership both at home and overseas, for only with an increasing subscription income can the Society increase its work and effectiveness. Efforts are currently being made through members to introduce 1000 new subscribers to *Spaceflight.* Long experience has shown that the part played by members in promoting the work of the Society and bringing it to the notice of others is a major factor in achieving an increased membership. Any member who feels that he has useful ideas to put forward in the cause of membership promotion should write to the Society. The *Membership* Committee may have a small formal membership, but it seeks to enrol the help of every member of the Society in its task of membership promotion.

Chairman: Prof. G. V. Groves

Vice-Chairman: G. V. E. Thompson

Members:

L. J. Carter	Dr. W. R. Maxwell
K. W. Gatland	Dr. R. C. Parkinson
A. T. Lawton	C. R. Turner

Secretary: A. D. Farmer

Executive Committee

As in previous years this Committee continues to report to the Council on all financial and staff matters. It also deals with any business that does not fall within the province of another committee, as well as all urgent business which cannot be dealt with earlier by the appropriate committee. The membership of the Committee is *ex officio.* It consists of the President, the two Vice-Presidents and the immediate past-President; and it can co-opt others for specialist advice as circumstances require.

Chairman: Prof. G. V. Groves

Vice-Chairman: G. V. E. Thompson

Members:

K. W. Gatland A. T. Lawton Dr. W. R. Maxwell

Secretary: L. J. Carter

MITCHELL SHARPE TO EDIT BIS SPACE HISTORY JOURNAL

We are pleased to announce that the distinguished Space Historian Mitchell R. Sharpe has agreed to edit the new Space History issues of *JBIS*. We believe that these issues will have wide international appeal.

Mr. Sharpe (FBIS) is currently the historian of the Alabama Space and Rocket Center in Huntsville, Alabama, USA. Formerly a historian with the Marshall Space Flight Center, also in Huntsville, he has for many years been a consultant to the National Air & Space Museum, in Washington, and also has been a member or advisor to the Technical Committee on History of the American Institute of Aeronautics. He regularly participates in the history symposia of the International Astronautical Federation and reads papers on the history of rocketry at the triennial International Congress for the History of Science. Sharpe's primary area of interest is rocketry prior to World War I and the non-military uses of rockets generally.

With BS and MA degrees from Auburn University, in Alabama, he has some 25 years experience as a technical writer and editor in the field of guided weapons and space vehicle development. In the mid-1950's, he was employed as a technical writer at Redstone Arsenal, in Huntsville, where he first became associated with the late Dr. Wernher von Braun and his team of former German rocket engineers and scientists who emigrated to the USA after World War II. While so employed, Sharpe wrote operation and maintenance manuals on a variety of antiaircraft missiles and large, free-flight rockets.

With the establishment of the National Aeronautics and Space Administration's Marshall center, in 1960, he joined that organisation, continuing his career with Dr. von Braun, the Centre's director. In addition to compiling specialised reports and bibliographies, he also helped to plan and manage the Center's Manned Flight Awareness programme, which was developed to increase astronaut safety and spacecraft reliability through the reduction of human errors. He later became senior historian of MSFC and helped prepare the official history of the Saturn launch vehicle programme.

A regular contributor to the *Britannica Book of the Year* and the *Britannica Year Book of Science and the Future,* Sharpe has also contributed many articles on aerospace historical subjects to other encyclopaedias, magazines, and journals in the USA and Europe. He is the author or co-author of eight books, the latest of which is *The Rocket Team*, scheduled for release by William Heinemann in June, 1979. It is the history of the von Braun rocket team from its formation in the early 1930's until von Braun's death.

Twice the winner of the Robert H. Goddard Historical Essay Award of the National Space Club (USA), he is also the holder of the Gold Medal of the Tsiolkovsky National Museum for the History of Cosmonautics, in Kaluga, USSR.

Mitchell R. Sharpe

SATELLITE DIGEST - 126

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed summary of the information presented can be found in the January 1979 issue, p. 41.

Continued from April issue]

Name, designation object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Cosmos 1070 1979-1A 11229	1979 Jan 11.63 13 days (R) 1979 Jan 24	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	205	296	62.80	89.52	Plesetsk A-2 USSR/USSR
Cosmos 1071 1979-2A 11233	1979 Jan 13.65 12.63 days (R) 1979 Jan 26.28	Cylinder + sphere + cylinder-cone 6000?	6 long? 2.4 dia?	178 156 164	338 301 405	62.79 62.80 62.79	89.66 89.07 90.21	Plesetsk A-2 USSR/USSR (1)
Cosmos 1072 1979-3A 11238	1979 Jan 16.73 1200 years	Cylinder? 700?	1.3 long? 1.9 dia?	963	1018	82.92	104.98	Plesetsk C-1 USSR/USSR (2)
Molniya-3 (11) 1979-4A 11240	1979 Jan 18.65 12 years?	Cylinder-cone + 6 panels + 2 antennae 1500?	4.2 long? 1.6 dia?	433 434	40816 39942	62.82 62.80	735.98 718.18	Plesetsk A-2-e USSR/USSR (3)
Meteor (29) 1979-5A 11251	1979 Jan 25.23 60 years	Cylinder + 2 panels 2200?	5 long? 1.5 dia?	621	643	98.00	97.41	Tyuratam A-1 USSR/USSR (4)
Cosmos 1073 1979-6A 11255	1979 Jan 30.64 13 days (R) 1979 Feb 12	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	181 162 158	327 319 378	62.81 62.80 62.81	89.58 89.31 89.87	Plesetsk A-2 USSR/USSR
SCATHA 1979-7A 11256	1979 Jan 30.90 indefinite	Cylinder 360	2 long 2 dia	180	43260	27.32	780.13	ETR Delta DoD/NASA (5)
Cosmos 1074 1979-8A 11259	1979 Jan 31.38	Cylinder + panels? 7000?	7 long? 2.5 dia?	197 308 364	240 322 384	51.60 51.66 51.63	88.80 90.76 91.96	Tyuratam A-2 USSR/USSR (6)

Supplementary notes:

(1) Orbital data are at 1979 Jan 13.8, 1979 Jan 21.7 and 1979 Jan 22.4. Two objects, one of which may have been a manoeuvring engine, separated from Cosmos 1071 during 1979 Jan 25.

(2) Cosmos 1072 may be a navigation satellite.

(3) 11th operational Molniya-3 communications satellite which is probably a replacement for Molniya-3 (8). Orbital data at Jan 21.3 and 26.8.

(4) Soviet Union's second Meteor weather satellite to be placed in a retrograde, Sun-synchronous orbit.

(5) SCATHA stands for Spacecraft Charging AT High Altitudes. Its purpose is to investigate the build up of electrical charges in spacecraft in the magnetosphere. Its orbit was chosen so that the satellite passes through geostationary altitude while over the equator because build up of static charges can be a particular problem with communications satellites.

(6) Further test of manned spacecraft or man-related craft similar to Cosmos 1001 (1978-36A). Orbital data are at Jan 31.6, Feb 3.5 and Feb 7.6.

Amendments:

1976-125A was de-orbited 1979 Jan 28.

1978-118A, Horizont, add further orbit of 22616 x 48955 km, 11.26 degrees, 1436.0 min. Orbital data are at 1978 Dec 28.1 and 1979 Feb 2.1.

MILESTONES/*Continued from page 194.*

26 Total eclipse of the Sun – visible in the northwestern United States and central Canada – begins at dawn over the Pacific Ocean, west of Puget Sound, and terminates at sunset over northern Greenland. Scientists in Western Ontario probed the upper atmosphere with sounding rockets. Twelve satellites, including Britain's Ariel 5, took measurements. (*The last total eclipse observable from the North American continent this century*).

26 Soyuz 32 docks with Salyut 6 space station at 16 hours 30 minutes (Moscow time).

27 Cosmonauts Vladimir Lyakhov and Valery Ryumin aboard Salyut 6 work from 10.00 a.m. (Moscow time) until 23.00 hours. They have mothballed systems of Soyuz 32 and begun to reactivate systems aboard the space station.

27 British Aerospace Corporation, reveals that formal contracts valued at £73 million have been signed with ESA for four communications satellites to be built by the Dynamics Group at Stevenage, leading the MESH consortium of European companies and payload contractors in West Germany, U.K. and Italy. Subjects of the contracts are two European Communication Satellites (ECS) and two MARECS, a maritime derivitive of ECS. Orders for up to three more ECS and a third MARECS are expected to follow. The satellites will be launched by the ESA Ariane from Kourou, French Guiana, beginning in 1980.

BOOK REVIEWS

The Rocket – The History & Development of Rocket and Missile Technology
By David Baker, New Cavendish Books, 1978, 276 pp. £12.50.

This is a large book and it contains a great deal more information than indicated by its 276 pages; each page measures 33 cm by 23.5 cm, and some fifty of these pages consist of a compendium of launch vehicles and ballistic missiles together with tabular information, all of which is in small print. There are about 350 illustrations, including two 6-page colour fold-outs and some 34 photographs and diagrams in colour.

The history of rocketry and its applications to weapons and space vehicles is covered from its early beginnings in the East to the present time. There is little that is over-looked although there is no mention of Achille Eyraud who made (in a work of fiction) the first serious suggestion of the reaction principle as a means of space travel; a more important omission is that of Hohmann and his book *Die Erreichbarkeit der Himmelskorper.* Developments in the Soviet Union are particularly well covered and the chapter dealing with these contains a lot of information which has not been widely disseminated. Sometimes, as in the description of German developments in World War II, there is almost too much "detail" for the general reader, especially in regard to the power struggles between individuals and groups of individuals within the Nazi organisation. A sketch map showing the location of the German ranges and research and development establishments would have added to the interest of this section. A similar comment applies to the information on the distribution of U.S. ballistic missile sites.

The book does not confine itself to technology but also deals with political aspects of space flight and rocket weapons, including the theory of nuclear deterrence. On the technological side one might have hoped for a more precise use of scientific and technical items. The author, unfortunately, persists in the loose practice of giving the units of specific impulse as seconds which results from confusing mass and force. Specific impulse has the units of velocity and is most unusually given as lbf sec/lb mass. If SI (Systéme International) units are used, as they should be, the specific impulse is numerically the same as the jet velocity and it is immediately apparent that a high jet velocity is synchronous with a high specific impulse. The term 'efficiency' when used in a scientific context has a precise meaning, as for example thermal efficiency, mechanical efficiency, but the author uses it in a loose colloquial sense. In one sentence on page 18 the term 'reactive' is used in both the chemical and mechanical sense which might be a little confusing to the uninitiated. There are a few errors of fact, among which might be mentioned the following: the Japanese Kamikaze plane (p.92) used three solid propellent motors for propulsion, *not* a liquid propellent motor, and the explosive in the warhead was trinitroamisole (not trinitroaminol); on page 141 it is implied that JPL invented the star-centred charge but in fact this charge shape was certainly known in the U.K. before World War II, and neither was the case-bonding concept attributed to JPL new (gunpowder rockets can be regarded as case-bonded); unsymmetrical hydrazine on page 180 should be unsymmetrical dimethylhydrazine; in the description of propulsion systems of Atlas on page 232 it is stated that '..... Pitch and yaw control was governed by the movement of the booster and sustainer engine exhaust nozzles...' This is incorrect as a liquid propellent motor with a movable nozzle is virtually unknown. In Atlas it is the combined combustion chamber and nozzle of the central motor which is movable, the combustion chambers and nozzles of the boosters being fixed.

The text is well printed and generally free from printing and proof reading errors, but the word 'ordnance' is repeatedly and consistently misspelt 'ordinance'. There is a good index.

To sum up, despite a few blemishes, this is a book which merits a place on the bookshelves of all those who are interested in the development of rocket motors for space and missile applications. Because it is profusely illustrated it is very suitable for browsing throught at leisure, or alternatively, because it contains information on almost all rocket missiles and space vehicles known to the Western world, it makes a very useful book of reference.

DR. W. R. MAXWELL

Spaceships of the Mind
By Nigel Calder, BBC Publications, 1978, pp. 144, £6.50

Nigel Calder is now well known for science popularisation programmes on BBC, like the one on which this book was based and with which it shares its titles. It uses much of the same material but in a different order and format.

Although the book presents a whole range of scientific frontiers it was given its 'Spaceships' title because space seemed to Calder to be the nucleus of so many of today's "big ideas". Of these the book presents a personal selective sampling rather than a comprehensive treatise. It is flavoured, too, by one prejudice, clearly expressed, *viz* that the 'dream of a better existence for man based on science (is) not yet extinguished' – a refreshing experience after the near-Luddite hysteria of recent years, and from which Calder claims to detect a 'scent of rennaissance'.

The book takes the form of encounters with and histories of 'experts'. We are introduced to J. D. Bernal, Tsiolkovsky, Dyson, O'Neill, Wassinck, John Todd, John Lewis, O'Leary and many others. 'Introduced to' is the operative phrase, this being a man-in-the-street popularised account. An avid reader of *JBIS* or *Spaceflight* will not find much new on the 'high frontier' side, except perhaps, in the way it weaves the separate strands together or with more prosaic enterprises like the New Alchemy Institute and Wassinck's ideas on the self-sufficient small city. Those who want more detail or who may wish to follow up any of the ideas will meet the disappointing facts that there is no real technical detail, and no bibliography.

Calder does, however manage to encapsulate neatly the *feel* of much of the new science. To give a flavour of the book here are some snippets gleaned from the text:-

(a) *On Space Colonies:* Most of the economic arguments for space development are infeasible, oversimplified and/or over-optimistic (*viz* Cleaver's remark on O'Neill colonies that 'engineering takes time'). If we go it will be because we are driven by the 'big ideas' involved. Only a small fraction of the human race will be in there pitching, but, as always, the real power will come from the unsung majority of them, not the captains – where would Columbus have been without a crew? In the long run it will be good that we went because any species needs to

diversify to survive, and, in the best Stapledonian manner, man will have to diversify genetically to survive up there for any length of time.

Who on any sane accounting basis could have foreseen a century ago the growth of that irrational industry, tourism, and what direct benefit kept thousands of Europe's craftsmen building over hundreds of years, Europe's great cathedrals?

(b) *On Ecological Systems:* Are small closed ecologies unviable as the Gaia hypothesis states? If so what does this mean for our space colonies? As a rider, why do we forget in our arguments about the effect man is having on the 'natural' environment, that man is already part of that closed ecology, has been for millions of years and cannot affect it.

(c) *On Space as a potential area for Overflow Population:* If we can get life out on a space platform and make it viable and self-sufficient there in the long run, then so much simpler would it be to build it in the deserts, Arctic wastes, or in the middle of the oceans. Ocean cities can be shown to be, in fact, potentially better supplied, if they tap the mineral and heat potential of the deep oceans, than many landbased sites.

(d) *On the anomalous situation of Industrial Civilisation:* Is it past the point of no return, as far as starting again – with all the high grade resources gone or going? This would suggest that if some disruption killed off industrial civilisation now, one could never re-emerge. Yet Wassinck's ideas on the city of the future do not use anything but the simplest of technological techniques to make it a compact self-sufficient unit, (and by so condensing even Earth's present population into many small centres he claims 80% of its surface could be allowed to revert to its 'natural' ecology).

These snippets give a good idea of the flavour of the book. There are plenty of illustrations, and the BIS gets a fair mention, though more by way of its membership than directly.

A. D. FARMER

The Realm of the Terrestrial Planets
By Zdenek Kopal, Institute of Physics, 1979, pp. 224, £7.50

If you have ever wondered why seasonal changes on Mercury should be *longitudinal*, speculated on the ultimate fate of the Earth-Moon relationship, or not considered Pluto to be a terrestrial planet, then this is the book for you. Professor Kopal writes critically and in not too technical terms about the vast amount of new information on the "solid" members of the Solar System produced in recent times by radar techniques and exploration by manned and unmanned spacecraft.

Following introductory chapters on the Solar System, lunar and interplanetary probes, the book deals with the Moon, Mercury and Pluto, Mars, asteroids and interplanetary dust, Venus and the Earth. Apart from a brief mention of "mascons" in chapter 2, there is no reference to, or explanation of, the localised concentrations of mass underlying the lunar maria. I looked in vain for a coloured picture of Venus among the 12 colour and 55 black and white illustrations which are very well reproduced. A diagram of the descent sequence for the early Veneras and the two surface pictures from Veneras 9 and 10 are the only illustrations of Russian origin.

It is the duty of a reviewer to point out errors of fact and instances of loose writing. The nine Apollo launches to the Moon were not successive launches in the series – Apollo 9 was an Earth-orbital mission (p.26). There are not two Pioneers *en route* to Saturn (p.37). It should have been made clear that the value of 7.92 km s^{-1} for the velocity of an artificial satellite of the Earth refers to an orbit at zero height above the surface (p.197), and I found the percentages quoted on p.46 confusing.

As a Fellow of the Institute responsible for the publication of this book and being deeply involved in education it grieves me to find that SI units are not used throughout; pressures in dyn cm^{-2} and energies in ergs are only dim memories and I was never very sure what a gamma was.

That said, perhaps I should end by saying that I spent my father-in-law's Christmas gift to me on a copy of the book for my personal collection!

GEOFF PERRY

Physical Processes in the Interstellar Medium
By Lyman Spitzer, Jr., Wiley, 1978, pp. 318, £11.25

It is ten years since the publication of Professor Spitzer's earlier book, "Diffuse Matter in Space," and in that period this book has become a classic in its field, serving as a standard text for students of astronomy and astrophysics and also for research workers. In that time, however, observational results have transformed many aspects of our understanding of this topic and several new fields have opened up, often resulting from observations from space vehicles. The time is therefore ripe for an up-dated version of the text and this is indeed what we have with the publication of Physical Processes in the Interstellar Medium. Most of the book is newly written but in each chapter some sections describing basic theoretical concepts are very similar to the corresponding parts of the original text. The use of cgs units has been generally retained. The emphasis of the book is very much on the theory of the basic physical processes involved in the interstellar medium. This is, of course, vitally important for any sound understanding of the observational results in this field. Description of up-to-date observations is less complete and these are often introduced to elaborate upon the theoretical discussions.

A book of this size could not possibly cover the whole topic in great depth and some selectivity is inevitable. The author's own background (he has recently been responsible for the ultraviolet telescope on the Copernicus satellite) appears to have influenced the emphasis of the topics, particularly in the description of recent observations. For example ultraviolet absorption line studies merit greater space than molecular line emission or infrared studies, and in particular, the rapidly developing fields of X- and γ-ray astronomy are only briefly touched upon. However since it is the theory of the physical processes that is the crux of this book, these omissions are not necessarily a shortcoming.

The study of the distribution of interstellar material is discussed in some detail and is of particular interest since it is a field in which observations at different wavelengths can be combined to produce a coherent overall picture. Optical observations show that the light from stars is absorbed by varying amounts, not simply dependent on the distance of a particular star. The statistical distribution of this absorption is used to show that the interstellar dust responsible for the absorption is distributed in a rather clumpy manner. The data requires the existence of two types of cloud, termed

standard and large clouds, and physical parameters for these are derived. 21 cm radio observations and ultraviolet absorption line studies give information on the distribution of interstellar hydrogen and the author shows that a correlation exists between the column density of hydrogen atoms in the line of sight to various stars and the amount of dust in the same directions. This shows that on the large scale, the dust-to-gas ratio is approximately constant. Recent observations with X-ray instruments have detected absorption effects in the soft X-ray spectra of some sources thus giving further information on the quantity of intervening interstellar material in various directions in the galaxy.

In conclusion, this book, by one of today's most eminent astrophysicists, can be strongly recommended to all serious students of interstellar medium studies and also to more established research workers wishing to approach some new aspect of this field. The fairly extensive list of references should prove particularly useful to them. Let's hope that we can now look forward to a further up-date on this subject from Professor Spitzer in 1988.

DR. J. C. ZARNECKI

The Large Scale Structure of the Universe.
I.A.U. Symposium 79, M. S. Longair and J. Einasto (Eds.), D. Reidel Publishing Company, 1978, pp. 464, approx. £25.00.

This volume is devoted to the topics discussed at the five day symposium held in Tallinn, Estonia, USSR in 1977. The book is divided into five main sections which treat the subject in some depth.

The first part, discussions on galaxies in small groups including binary systems, leads naturally and purposefully into the next which is concerned with clusters of galaxies. These two sections and the third on large scale systems all rest upon deductions from the most recent observations and the astrophysical problems posed by their interpretation. Section four is given entirely to the observational evidence for, and the effects of, cosmological evolution.

Besides the main papers, short communications have been included to give a broad coverage of the topics under discussion. It is an adage that books are very fine but cannot be asked questions in order to clarify a difficult passage. This is, of course, true, but in the case of this volume we have the next best thing, the discussions after the lecture has been delivered. These are both fascinating and highly illuminating and form a welcome supplement to the main text.

One problem which mars several papers is the reference to films which have been shown and I feel that a synopsis of the films would, in most cases, prove helpful in determining what the authors intended to demonstrate with them. For example, the extremely short communication by Tully and Fisher entitled "A Tour of the Local Supercluster" is meant to complement a film shown at the symposium. As no details of the film are given the article is not particularly illuminating. However, the article does contain three pairs of pictures which, when viewed with the proper viewer, give stereographic diagrams of the local supercluster. The authors point out that, should a viewer not be at hand, the effect may be obtained with some difficulty by splitting the images with a card and viewing from a distance of 15 cm. On trying this technique I find that either it is virtually impossible or that my eyes are set too close together for three-dimensional vision.

One of the outstanding problems is whether or not clusters of galaxies are themselves clustered. The general concensus of the papers presented here is that superclusters do in fact exist on scales around 30-100 Mpc. Also it seems that over scales of 50-100 Mpc "holes" exist and there is a definite "cell structure" with galaxies forming interlocking chains.

The most exciting section of the book is the final one on the formation of structure in the Universe. The Moscow groups, in particular, have produced some very original ideas in this field which may be classified into two main schools of thought, i.e. Zeldovich and colleagues' isothermal models *versus* Ozernoy's whirl theory. Here we have the beginnings of a controversy to rival that between the "Big Bang" and "Steady State" theories and which will certainly spur further work into the physics of the early stages in order to resolve which theory (if any) is correct.

Although the price is high enough to deter most people from buying this book, I strongly recommend it to anyone with an interest in the structure of our Universe. Once again the I.A.U. and D. Reidel have, between them, produced a book which is stimulating, informative and of the high standard that we have come to expect.

T. G. COOK

BIS DEVELOPMENT PROGRAMME

BOOK REVIEWS BY OVERSEAS MEMBERS

The Publications Committee plans to expand the Book Reviews Section in "Spaceflight" to include a wider coverage of books in English which are published abroad. Overseas members could provide a useful service in bringing such books to our attention, because publication may not necessarily take place in the U.K. until some years afterwards.

Those overseas members with access to books suitable for review, particularly of a technical nature, are invited to notify the Society. A brief note of the title, author and address of publisher would enable us to confirm our interest in publication, or otherwise, avoid duplication by other members, and also avoid confusion where e.g. the same book appears in different countries but under slightly different titles.

Additionally, it will give the Society an opportunity to obtain a copy of the book for its Library. This is essential as many members may wish to borrow the book on the appearance of the Review, and avoid the considerable difficulty which has sometimes arisen in the past where members have submitted details of books which are no longer freely available, i.e. have just gone out of print, and so caused considerable disappointment to other members who wished to obtain copies!

Overseas members planning to submit Reviews of books should always first notify the Secretary of the appropriate details and obtain from him confirmation that a review is acceptable and an indication of the length required.

Since the Society prints in the English language, Reviews should normally be only of those books published in English. (Many books appearing in other languages appear subsequently in English, or have already been translated into English). This policy is made obligatory mainly through the relatively small amount of space available to us for the inclusion of Book Reviews and the need to publish only those items likely to prove of interest to many other readers.

We are interested in Reviews of books above graduate level in all branches of astronomy, and all areas of space research and technology. Reviews of technical works will be particularly welcome, though some of these may be appearing in JBIS rather than "Spaceflight", as appropriate.

CORRESPONDENCE

Road to the Stars
Sir, I have found your Correspondence pages especially thought-provoking recently, particularly letters such as that from Iain R. Simpson (*Spaceflight*, January 1979, p.48). It seems to me that we are exceptionally fortunate in being alive at the time when Man is first breaking free of "the cradle of the mind". I am sure that many generations from now, when our descendants are scattered amongst the stars, they will look back and see in the century following 1957 the great Watershed in the history of mankind. This was when the real 'action', the real history of Man began. The great venture which has started in the life-time of most of the members of this Society will continue as long as Man exists. Its effect on the thoughts, deeds and evolution of men and women everywhere will surely be of a magnitude inconceivable even to the most optimistic.

I myself am a "child of the Space age". I cannot remember a time when men had not orbited the Earth or the words "*Via* Satellite" were unknown on T.V. Therefore my debt to the original members of the Society is all the greater. They had the courage to stand by their ideas at a time when in informed circles it was well known that space flight was "utter bilge". I can only wonder with some trepidation if I would have had that courage!

The honour that history has bestowed upon us also brings great responsibility. We will choose if the rocket opens the road to the stars or if it is the instrument of destruction for all the human race has ever worked for or dreamed of.

To me the choice is obvious. The stars have always been symbolic of the unattainable; now they are an ultimate challenge to which we must eventually respond.

One *final* point. I suggest something symbolic for the BIS insignia rather than anything which will be dated by changes in technology. Perhaps the winged horse Pegasus.

JEREL HEATH WHITTINGHAM
Telford, Salop.

Aiding the Space Venture
Sir, Congratulations on the extraordinary DAEDALUS issue; I cannot assess its full importance, and I do not know the English word to express all I feel. I wish I could thank everyone personally....

Spaceflight is better every issue; more pages is really good news for me. I do not have the time to read the sparce information newspapers provide or go the American Library Service which is, to the best of my knowledge, the only place where one can read more than a few lines about the space venture. So the BIS is my only link with what I consider to be the second Achievement of Man after fire.

Your Progress Report on the new Headquarters Building is a really good idea. Maybe by the end of April 1981 we shall have reached the £75,000 mark?

Now that the owner of my flat is trying to get rid of me, I can really feel the BIS problem. If I am to buy my "new premises" I have to raise a £20,000 fund. See what I mean? Well, this is my problem. Please find enclosed a cheque in the amount of £26.00, £3.50 of which is to the Development Fund Appeal. To help solve OUR problems....

FERNANDO EMANUEL NOGEL
Lisbon, Portugal.

Why Weren't We Axed?
Sir, I am writing this letter after reading about Project Daedalus in *Hobby Electronics*, January 1978, and I would like very much to know something about your Society. There are a few things that intrigue me. I was not aware that there were any further space programmes being planned for the U.K., and I may ask: Why wasn't the BIS disbanded after space programmes ceased in Britain?

You are to be congratulated on your "Project Daedalus". It was a truly brilliant piece of engineering and I was fascinated by the way in which the study was executed.

I understand that you had done a feasibility study some thirty years before Apollo 11!

I would be grateful if you could send me further information on your Society. I am interested to know, for example, why it is still in operation and why these men chose to do the project in their own time.

Would it be possible for me to receive a copy of these projects and possibly join the BIS myself?

RONALD C. FULTON
Castlepark, Irvine.

We never cease to be amazed by the number of people who believe that Britain has opted out of Space. Much of the fault undoubtedly lies with the British press which so often fails in its duty to report space events in which the U.K. is deeply involved. Many people assume that the BIS is somehow supported by government funds whereas the truth is that we have always had to make our own way – by the enthusiastic support of members and friends giving their free time to an ideal which they consider profoundly worthwhile. We thank Mr. Fulton for his unsolicited tribute to the Daedalus team. Where else indeed could a body of people be found who were prepared to give over 10,000 hours of talent to the cause of defining an advanced engineering concept for the Future without monetary reward? All profit made from the Daedalus Report goes, by consent, into BIS Funds. – Ed.

Concrete Spaceships?
Sir, Dr. Sheppard has pointed out that it is desirable to build the Lunar and Lagrange 5 colonies from concrete, [1-2]. Having built the Lagrange 5 colony, it would obviously be cheaper to use the facilities established on the Moon, and at Lagrange 5, to build interplanetary and interstellar spaceships also out of concrete.

Dr. Sheppard says that the survival of space colonies will depend on their economic self-sufficiency. It seems obvious to me that one of the prime industries at these sites will be the spaceship construction industry based on 'low' technology, it being cheaper to make a concrete spaceship with the Lagrange 5 workforce, than a similar structure in low Earth orbit. However, since concrete will not lend itself easily to an aerodynamic structure the ferryship to be carried aboard the interplanetary craft would have to be made by 'high' technology, either on Earth, or in Low Earth Orbit.

Furthermore, a concrete spaceship would survive the micrometeoric erosion better than metal. The walls of such a craft would obviously be thick – which is advantageous from a habitat point of view – but this would result in a heavier craft than one based on 'high' technology. Interplanetary probes will be large anyway by the necessity to carry sufficient supplies and back-up stores as well as a reasonably large crew, and the ferryship to actually land on the planet. The extra mass of concrete over metal might therefore be a small proportion of the total mass.

Looking even further to the future the construction

company based on the Moon and Lagrange 5, might prove so successful that it may find it lucrative to build small space stations – perhaps of the cartwheel design – for insertion in low Earth orbit, or in orbits around Mars and Venus. A number of space tugs would be required to tow the station from the construction site at Lunar Lagrange 5 to the planet, but the cost of this manoeuvre would be offset by the comparative low cost of launching rock from the Moon's surface, and of the 'downhill' gravity gradient from the Moon to the Earth. A similar station in orbit around Mars would still be cheaper to be made at Lunar Lagrange 5, since it would involve no further transportation of construction teams and equipment.

GEOFFREY HUGH LINDOP,
Cardurnock, Carlisle.

REFERENCES

1. D. J. Sheppard, 'An Alternative Technology for the Lunar Colony,' *Spaceflight*, **19**, 47, 1977.
2. D. J. Sheppard, 'Concrete Space Colonies,' *Spaceflight*, **21**, 3, 1979.

Types of Asteroids

Sir, Regarding the comments made by Anthony T. Lawton on the nature of asteroid bodies in his recent article (*Spaceflight*, January 1979, p. 8). There are *apparently* more silaceous asteroids than carbonaceous types, but this is due to the selection effect which occurs in the observation of these objects, i.e. we tend to study those asteroids which are the brightest (they have high albedos, or are studied in the inner regions of the asteroid belt) [1].

Research during the past few years has shown that, allowing for selection effects, it is clear that carbonaceous surface types are the most common, and such asteroids become more frequent as one moves out through the asteroid belt. (It has been estimated that the carbonaceous types make up about 95% of those bodies situated at the outer edges of the belt). The determination of asteroid surface types is carried out by comparing and matching the spectra (of wavelength ν albedo) of the minor planets with the reflectivity characteristics of laboratory samples (such as meteorites and lunar and terrestrial rocks).

If the mass and surface type of asteroid *Herculina* are found, then one may speculate concerning the internal structure and constitution of this body. A mean density for the asteroid in excess of that as suggested by the material of the surface type, would lead us to infer the presence of some higher density core within the body. Such information would be helpful in that it could tell us about the role of differentiation for the minor planets.

HOWARD HAIGH,
Eccles, Manchester.

REFERENCE

1. Keith Hindley, "Pebbles in the Sky," *New Scientist*, pp. 361-363, 10 November 1977.

Naming Celestial Bodies

Sir, It seems that in the not-too-distant future, the existence of planets orbiting nearby stars will be confirmed. These will require names, as (probably) will the stars, for the purposes of poets and songwriters if nothing else.

It is tempting to suggest that names from classical mythology might be used, but these are rapidly being used up in our own Solar System. Names from other ancient mythologies (e.g., Hindu, Celtic, etc.) are likely to go the same way.

One of the few remaining sources of names is the modern equivalent of these ancient mythologies, science fiction. Many superb names, such as Jinx, Wunderland, Magarathea and Belzagor, appear in novels and broadcasts. Names for stars also, although less common, can be taken from S.F. This would give a measure of immorality to S.F. writers, without whom space research might never have progressed this far.

PETER G. YULE,
Peterhead, Grampian.

'Ad Novae Mundi'

Sir, May I congratulate you on the new "Third Generation" *Spaceflight*! The increased monthly payload is most welcome.

I was interested to read the correspondence on the Society's name and badge. I have had a "patch" on my jacket for three years and it has sparked many an interesting conversation (though no new members I'm afraid). Most people are initially intrigued by the fact that it is British! So perhaps we should keep the name for a while.

On the subject of a Society motto, I feel that *Ad Astra* is the best suggestion, although the R.A.F. seem to have beaten us to it! (but without wishing to offend, it has always seemed a rather irrelevant motto for them to adopt!)

I wonder if *Ad novae mundi* (To new worlds – if my rusty latin is not too bad) would be more appropriate as this would bring in the planetary concept? By implication the stars are there too – but it can apply equally well to exploration of the Solar System.

P. HATCHETT,
Caister-on-Sea, Yarmouth, Norfolk.

Cosmonauts from Eastern Europe

Sir, There have been several mentions of Cosmonauts from East Germany, Czechoslovakia and Poland in *Spaceflight* over the last several months, and I am wondering whether or not this is just a ploy by the USSR for publicity for their space programme. One indication of the validity of such speculation would be to know how much space flight training these cosmonauts from Eastern Europe have had before their missions in Soyuz spacecraft. It would be interesting to know either way.

WILLIAM S. SMITH,
Ypsilanti, Maryland, USA.

Society Name and Motto

Sir, Regarding the question of the Society's name I agree with Mr. G. W. Wood (Correspondence, *Spaceflight*, December, p. 440) that we can do without the few people silly or ignorant enough to be put off by the original and present name.

I also support very strongly the suggestion by Mr. Jonathan McDowell (letter in the same issue) that the BIS adopt the motto 'PLUS ULTRA'. I think that this is extremely expressive and most fitting.

IAN HURRELL,
Lymington, Hampshire.

'Mastermind'

Sir, Members may be interested to know the rest of the story about my appearances on *Mastermind*, to which you

gave such generous space in the January issue (p. 40). As viewers of the programme will know, by the time the item appeared the story was well over, in that both the semi-finals and, indeed, the final had been shown.

My semi-final was shown on the 7 December, and – well, if my comparative success with questions on Manned Space Flight and Librarianship are anything to go by, I definitely should be an astronaut rather than a librarian! (I am not actually working in libraries at present, though I did so for over ten years). I came third, with an overall score of 17: 7 on Librarianship, and 10 – exactly the same as in my first appearance – on general knowledge. The winner's score was 29, and in a way I am glad that the gap between him and me was so great; *Mastermind*, because of the time limit, is as much a matter of being able to call the answers to mind very quickly as of simply knowing them, and if there had been only a few points in it I would still be kicking myself over the questions whose answers I knew but couldn't at the time call to mind. I originally intended to call the subject Libraries and Librarianship, since I thought that might sound more interesting. I finally decided on just Librarianship, and then it turned out that many of the questions *were* about libraries rather than librarianship. But, as I've said, I would have had to be very good indeed to beat the winner whatever the questions, so I am not complaining!

Several news items about me, and a photograph, appeared in the local press at the time of my first appearance, and my membership of the BIS was mentioned, together with the news that an account of my appearance would appear in a Society magazine.

Those who saw the whole series will know that the contestant who tied with me in the first game, whom I was declared to have beaten on the respective numbers of passes, had her revenge in spectacular style! This was Rosemary James, a teacher from York, who was one of the four chosen to take part in the usual semi-final for the best runners up. This she won, thus getting into the final, which was shown on Boxing Day, and in which she triumphed in very convincing fashion! This is the second year running that the eventual *Mastermind* has come from the best runners-up semi-final. I have conveyed my hearty congratulations to Rosemary, who now goes into an international version of the show, and Britain couldn't have a better representative.

RAY WARD.

See page 240. Ed.

'Supermind!'

Sir, I enjoyed watching Senior Member Ray Ward on *Mastermind*, and was sorry that he did not in fact reach the final.

I feel, however, that I should point out that this was not the Society's first encounter with the *Mastermind* chair.

In December 1976, as the winner of the *Brain of Mensa* competition I competed against the *Mastermind* of that year (Mr. Roger Pritchard),the *Brain of Britain* (Mr. Thomas Dyer) and a representative of *Round Britain Quiz* (Miss Irene Thomas) in a programme called *Supermind*, which was transmitted towards the end of the month, shortly after the *Mastermind* final. I took as my special subject Astronomy, the questions being also set by Patrick Moore (BIS Fellow).

Notwithstanding the formidable opposition, I was fortunate enough to win, and was rewarded with a handsome trophy of Caithness glass, and the resounding title of *Supermind* of 1976.

WALTER DOBSON, AFBIS.,
Stockton-on-Tees, Cleveland.

Pipe Dreams?

Sir, I have located a reference to a pipemaker who may be the "Watts" mentioned in the letter from A. T. Lawton (*Spaceflight*, January 1979, p. 44) regarding the clay pipes found beneath the Society's new offices.

The reference appears in *Collectanea Londiniensia* (London and Middlesex Archaeological Society, Special Paper No. 2, 1978. Eds. J. Bird, H. Chapman and J. Clark). Page 346 of this Volume contains an article by Adrian Oswold entitled "New Light on Some 18th Century Pipemakers of London" which attempts to identify them by the insurance policies taken out with the Sun Insurance Company at that time.

Among those listed appears the name of a pipemaker called "Valentine Watts," his policy being dated 1749, i.e. nearly 100 years earlier than the date provisionally attributed by Mr. Lawton.

He might well be the maker of the pipe discovered.

L. J. CARTER,
London, S.W.1.

Pipe Dreams? – 2

Sir, It is difficult to judge from the drawings but these pipes look to be 18th century, not 19th. The pipe labelled 'navvy' seems to be a type common in the early 18th century, say 1720 to 1750 rather than the heavy 19th century type. The pipe with the maker's mark, called a 'Churchwarden', is a type common in the period 1770 to 1820 and this type of maker's mark with the full name in a circle and a foliage was also typically in use in the same period. I do not have anything like full pipemakers lists for London but I do know of three 'Watts'; these are:

(1) John Watts of Whitechapel who took an apprentice in 1731; this is perhaps too early for him still to be working 40-50 years later and he is the least likely of the three.

(2) Valentine Watts of Lambeth who took out a £200 insurance policy with the Sun in 1749. This is the most probable of the three and more information could be obtained as the Sun Insurance records are still available.

(3) John Watts of Drury Lane who appears in a trade directory of 1828 is also a possibility.

Pipe making tended to run in families and it may be that these three are related and that other members of the family were also involved. It would be interesting to compare the address for Valentine in the insurance records with that of the new BIS headquarters building; his works might have been close by.

Incidentally, the use of the name 'Churchwarden' is not strictly correct. This name was introduced in the early 1960's, for a particular style of pipe, not necessarily a long one, produced by the manufacture Southorns of Brosely in Shropshire. The name was fairly rapidly adopted for any long pipe, however, and seems to have been so used by the mid-1880's. The long pipes were originally known as 'aldermen' or 'straws'.

BOB FLOOD,

Clay Pipes: Connection with Drury Lane

Sir, With reference to Mr. Lawton's note on the clay pipes discovered on the site of our new Headquarters, the earlier

pipe was probably made by John W. Watts who was working from Parker Street, Drury Lane in 1828. I am afraid I can tell you nothing more about him but it is fortunate that the name rather than the initials appears on the pipe as there were no less than ten pipemakers with the initials J. W. W. in London at that time.

NORMAN PLASTOW,
Wimbledon.

The item describing the discovery of the 19th century clay pipes appeared in our issue of January 1979, p. 44. Ed.

Carrying the Space "Torch"

Sir, The forthcoming 50th anniversary of the BIS reminds me of the part which the Society has played in the formation of many other astronautical groups throughout the world which has never been mentioned before in any of the articles in its history.

Our own Argentina Interplanetary Society, for example, formed in 1947, owes much to the BIS inspiration and example.

I learned of the existence of the BIS in 1946 so I became a member and my first call was on the late Prof. A.M. Low, the Society's pre-war President. At that time I could not speak more than a few words of English, but that was enough. Perhaps I understood half, or only one-third of what Prof. Low was saying to me, but it was enough to fill me with his conviction and his enthusiasm for space. That was more than I had expected.

The letter from Mr. Ananoff inviting me to the first International Astronautical Congress in Paris, on his initiative and that of the BIS and the German Society, the Gesellschaft für Weltraumforschung, was decisive. At that time the BIS membership was 900, that of the French Society 250, and that of GFW 300. The membership of my own Society was 60.

Next I visited the BIS Secretary in London. Mr. Carter was very kind and gave me a lot of help: I remember we were talking about BIS activities – and ours – while we were walking through St. James' Park, ending at a corner where we stopped to drink coffee. I took profit from that conversation and became even more enthusiastic about space activities.

Ten years after the Paris meeting I founded the National Commission for Space Research in Argentina, being the President for ten years. This was a government organisation, under the aegis of the Air Force, so we could organise research at many universities and develop our own rockets at Air Force establishment. By 1970 we had developed a rocket able to reach an altitude of around 500 km with a 50-100 kg payload.

I am constantly struck by the fact that so many of those who played a major part in the formation of astronautical societies around the world were, additionally, members of the BIS. I cannot fail but think that it must have been because the BIS and a few others provided the inspiration and carried the Space "torch" around the world.

Daedalus is yet another and the most recent example of this work.

I hope the Society will long continue to discharge its tasks to its high and inspired standards.

TEOFILO M. TABANERA
President, Sociedad Argentina Interplanetaria,
Buenos Aires, Argentina.

History of Soviet Spacecraft

Sir, As a graduate student in physiology, I am extremely interested in the many and varied life science investigations in space. A life-long enthusiasm for space flight has provided me with some familiarity with the craft that ply the skies. In recent years, these two interests have become entwined, with the revelation that the Soviet Union's biosatellite is the venerable, but updated, Vostok. Accustomed to the American policy of limited editions, I never expected to see any spacecraft still going strong after nearly twenty years, and in such diverse disciplines as reconnaissance and life sciences. Naturally, my curiousity is piqued.

It would be most gratifying to read in your excellent publication some thorough account of Vostok's history, from its first flights in 1960, through the Voskhod project, and into its various applications in later years. Some indication of the number constructed and launched, and their fates after recovery (surely there is no such thing as a Vostok graveyard!) would be welcome. Perhaps, someone with access to such information could enlighten those of us less fortunate.

Indeed, the same treatment could be applied to the Soyuz-Zond-Progress family of craft, whose political history has already received good coverage in your journal [1]. This might be appropriate, in light of the recent observation that a Soyuz-class vehicle may soon relieve the shorter-duration Vostok-variant of its reconnaissance responsibilities [2].

Of further interest might be some general history of life-science investigations in space, going back to the first "inhabited" sounding rockets and manned-capsule dog and monkey flights, and including the various ballistic and orbital launches made by scientists from different nations for specific experiments. I'm toying with the idea of doing one such myself, if no one else is so inclined.

This type of retrospective seems appropriate now, on the eve of the Shuttle-Spacelab flights, and their capability of accommodating large-scale experiments. Perhaps a glimpse of the hurdles the earlier investigators overcame, for their brief moments of data, would be an inspiration to those who would follow in their tracks.

JOHN B. CHARLES,
Lexington, Kentucky, USA.

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1. For example: James Oberg, "The Hidden History of the Soyuz Project," *Spaceflight*, Aug-Sep., 1975, pp. 282-289.
2. James Oberg, "Salute to Salyut," *Analog*, Dec., 1978, pp. 50-67.

MASTERMIND INTERNATIONAL. The international competition mentioned by Ray Ward (p. 239) was broadcast on 28 February. Although Rosemary James did well, the contest was won by the Irish competitor.

EARTH GETS A HALO

Concluded from page 196]

11. Farquhar, R. W. and Kamel, A. A., "Quasi-Periodic Orbits about the Translunar Libration Point," *Celestial Mechanics*, 7, 4, June 1973.
12. D'Amario, L. D. and Edelbaum, T. N., "Minimum Impulse Three-Body Trajectories," *AIAA Journal*, **12**, April 1974.
13. Breakwell, J. V., Kamel, A. A. and Ratner, M. J., "Station-keeping for a Translunar Communication Station," *Celestial Mechanics*, **10**, November 1974.
14. Breakwell, J. V. and Brown, J. V., "The Halo Family of 3-Dimensional Periodic Orbits in the Restricted 3-Body Problem," AIAA Paper 76-825, August 1976.
15. Farquhar, R. W., Muhonen, D. P. and Richardson, D. L., "Mission Design for a Halo Orbiter of the Earth," *Journal of Spacecraft and Rockets*, **14**, March 1977.

16th EUROPEAN SPACE SYMPOSIUM

During 1979 the Council will be actively promoting a number of steps to expand the Society's activities in the International scene. Among the more important of these will be the extension of the European Space Symposium into a three-day annual event.

The BIS has long been associated with its sister Societies in Europe (DGLR, AAAF and AIDAA) in holding international meetings directly concerned with promoting and fostering European participation in Space.

At the IAF Congress in Dubrovnik, the four Societies agreed to reconvene these meetings on an enhanced basis and to seek even greater participation from the European Scientific and Technical Communities.

Our Call for Papers appeared last month and is repeated below.

Theme: **CURRENT AND POTENTIAL EUROPEAN SPACE PROJECTS**

To be held in Stresa, Northern Italy, on 3-5 July 1979, co-sponsered jointly by the DGLR, AAAS, AIDAA and BIS.

Technical Sessions will be devoted to the following main subject areas:

(1) Spacelab and Supporting Activities

(2) Technology of Space Vehicles (Satellites and Launchers)

(3) Space Applications

(4) Future Trends

Offers of Papers are Invited. Please contact the Executive Secretary for further information.

Please bring this to the attention of all your colleagues who ought to know about this Meeting and who might wish to submit Papers or to attend and take part in the discussions.

Details of the programme and other arrangements will be published as soon as these have been completed.

3rd BIS CONFERENCE ON INTERSTELLAR STUDIES

The Society has previously held two conferences on the topics of Interstellar Travel and Communication, in 1976 and 1977. In organising the 3rd Conference in the Series the title has been changed to indicate the wide range of topics which have been discussed, and a longer time has been allowed between conferences to aid the preparation of material.

The Conference will be held in the Chemistry Lecture Theatre, University College, London, W.C.1., on **11-12 September 1979.**

The scope of the Conference is intended to cover all aspects of Interstellar Studies, including such topics as:

- Propulsion concepts
- Interstellar probes
- Extra-solar planetary systems
- Laser and radio communication
- Evolution of life
- Rise of intelligence and civilisation

Papers have already been promised on propulsion systems, exobiology, human expansion into the Galaxy and the evolution of intelligence.

It is planned to allow ample opportunity for discussion to take place among the participants, both informally and in final discussion sessions.

Papers presented at the Conference will be published in the Interstellar Studies issues of *JBIS*, following usual reviewing procedures.

Applications for registration forms and notification of the intention to submit a paper for the Conference should be made to the Executive Secretary of the Society.

VIII IFAC SYMPOSIUM: AUTOMATIC CONTROL IN SPACE

Oxford, UK 2-6 July 1979

Sponsored by: International Federation of Automatic Control (IFAC).

Organised by: The Institute of Measurement and Control on behalf of the United Kingdom Automatic Control Council (UKAC) and co-sponsored by The British Interplanetary Society.

Topics

The IFAC Space Committee is concerned with the areas of:

Automatic control
Open and closed loop control and stabilisation
Man-in-the-loop control
Remote control
Combinations of these modes

in space and space related investigations and applications of which some specific fields are:

Space launch and landing systems
Spacecraft and satellites (including rendezvous problems)
Space laboratories and telescopes
Aerospace systems
Planetary and earth/space related surface systems
Use of spacecraft and terrestrial navigation
Underwater systems
Inertial systems for underwater positioning
Manipulators, tele-operators
Space experiments
Navigation, guidance and control systems (including components such as sensors, effectors and power control)

Offers of papers are invited for presentation at this meeting. Further information is available from the Executive Secretary, British Interplanetary Society, 12 Bessborough Gardens, London, SW1V 2JJ, England.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London, SW8 1SZ.

Correspondence and manuscripts intended for publication should be addressed to the Editor 27/29 South Lambeth Road, London, SW8 1SZ.

Opinions in signed articles are those of contributors, and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

General Meeting
Title: **SPACE MISCELLANY – 3**
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **9 May 1979**, 6.30-8.30 p.m.

Two contributions will be presented:

(1) Satellite Tracking – Some Problems and Results by M. Sweeting.

(2) The Day They Launched a Woodpecker by J. I. Stone.

Members interested in presenting short contributions to later meetings of this nature are invited to send details to the Executive Secretary.

Admission tickets are not required. Members may introduce guests.

VIII IFAC International Symposium
Theme: **AUTOMATIC CONTROL IN SPACE**
Sponsored by the International Federation of Automatic Control: Organised by The Institute of Measurement and Control on behalf of the U.K. Automatic Control Council and co-sponsored by The British Interplanetary Society.

To be held in Oxford, **2-6 July 1979**.

Further details appear on the back inside page of this issue.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society.

16th European Space Symposium
Theme: **CURRENT AND POTENTIAL EUROPEAN SPACE PROJECTS**
To be held in Stresa, Northern Italy, on **3-5 July 1979**, co-sponsored jointly by the DGLR, AAAS, AIDAA and BIS.

Further details appear on the back inside page of this issue.

Offers of papers are invited. Please contact the Executive Secretary for further information. Programmes and Registration forms will be available on request in due course.

Informal Talk
Title: **AN EVENING WITH ARTHUR C. CLARKE**
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **28 August 1979**, 7.00-9.00 p.m.

Admission tickets are not required. Members may introduce guests.

3rd BIS CONFERENCE ON INTERSTELLAR STUDIES
The Conference will be held in the Chemistry Lecture Theatre, University College, London, W.C.1. on **11-12 September 1979**.

Further details appear on the back inside page of this issue.

Applications for registration forms and notification of the intention to submit a paper for the Conference should be made to the Executive Secretary of the Society.

34th ANNUAL GENERAL MEETING
The 34th Annual General Meeting of the Society will be held in the Tudor Room, Caxton Hall, Caxton Street, London, S.W.1. on **13 September 1979**, 7.00 p.m.

A detailed Agenda will appear in *Spaceflight* in due course.

Meanwhile, Nominations are invited for election to the Council. Forms can be obtained from the Executive Secretary. These should be completed and returned not later than **20 June 1979**.

Should the number of Nominations exceed the number of vacancies, election will be by postal ballot. Voting papers will then be prepared and circulated to all members.

30th IAF Congress
The 30th Congress of the International Astronautical Federation will be held in the Deutsches Museum, Munich, Germany from **17-22 September 1979**.

Theme: **SPACE DEVELOPMENTS FOR THE FUTURE OF MANKIND**

Details of the technical sessions were listed on page 176 of the April issue of *Spaceflight*. Members wishing to present papers and requiring further information are asked to contact the Executive Secretary.

A particular invitation has been extended for papers to be presented at the Student Sessions of the Congress: these must be submitted through an IAF Member-Society.

BIS members, both from the U.K. and overseas who plan to attend the Congress are asked to notify the Executive Secretary accordingly.

Lecture
Title: **BEYOND SATURN** by Dr. G. E. Hunt.
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **9 October 1979**, 7.00-9.00 p.m.

Admission tickets are not required. Members may introduce guests.

3rd Computers & Space Technology Conference
Theme: **IMAGE PROCESSING TECHNIQUES APPLIED TO ASTRONOMY & SPACE RESEARCH**
To be held at the SRC Appleton Laboratory, Ditton Park, Slough, Bucks on **15-16 November 1979**.

Topics will include:

a) Astronomical Image Processing

b) Planetary Imaging

c) Remote Sensing

d) Interactive Processing and System Design

e) Applications of Array Processors

f) Image Restoration

Offers of papers (including a 300-500 word abstract of the proposed paper) should be sent to the BIS Executive Secretary, 27/29 South Lambeth Road, London, SW8 1SZ, England.

Lecture
Title: **THE INTERNATIONAL SOLAR POLAR MISSION** by D. Eaton (ISPM Project Manager)
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **21 November 1979**, 7.00-9.00 p.m.

Admission tickets are not required. Members may introduce guests.

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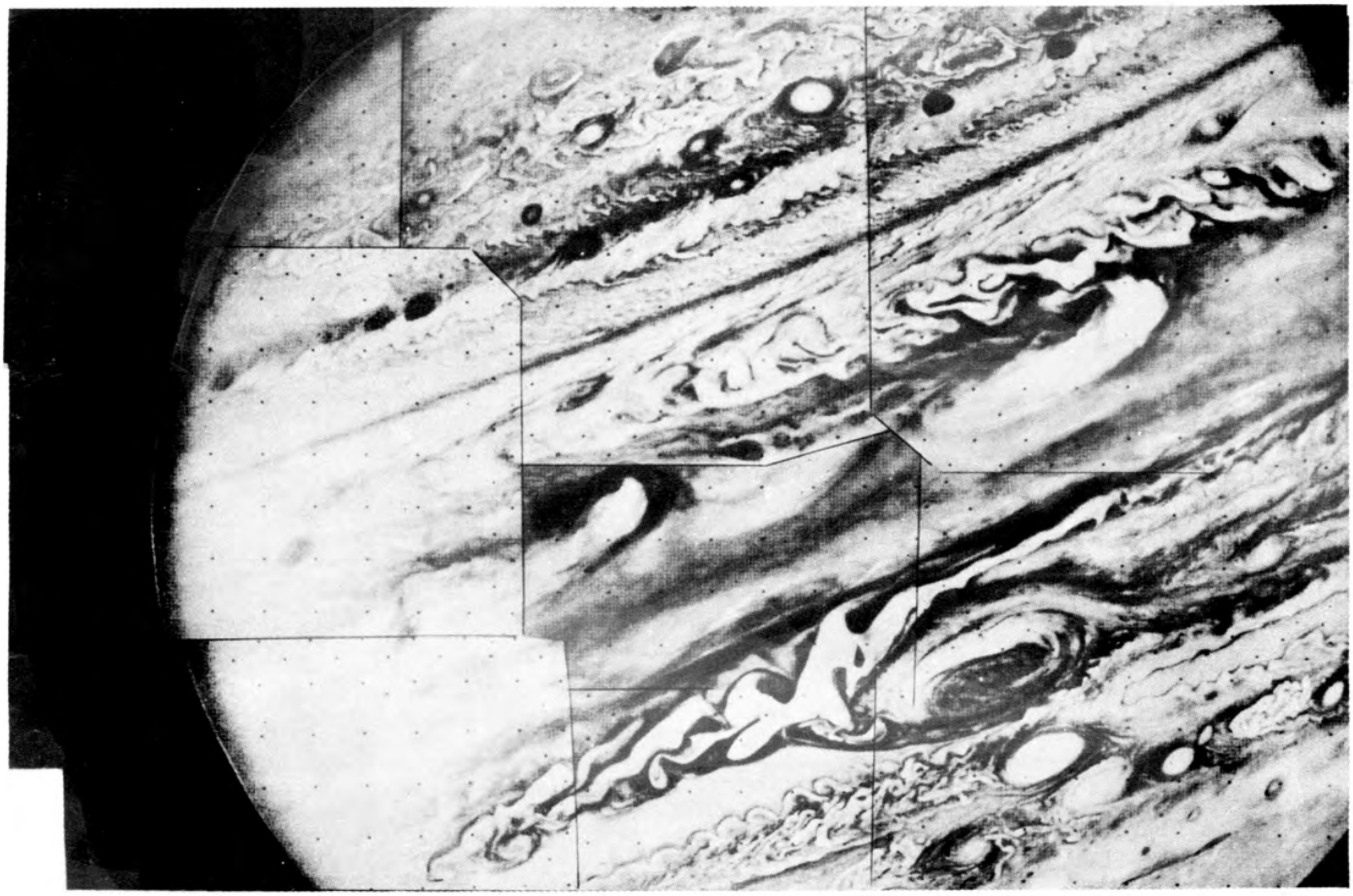

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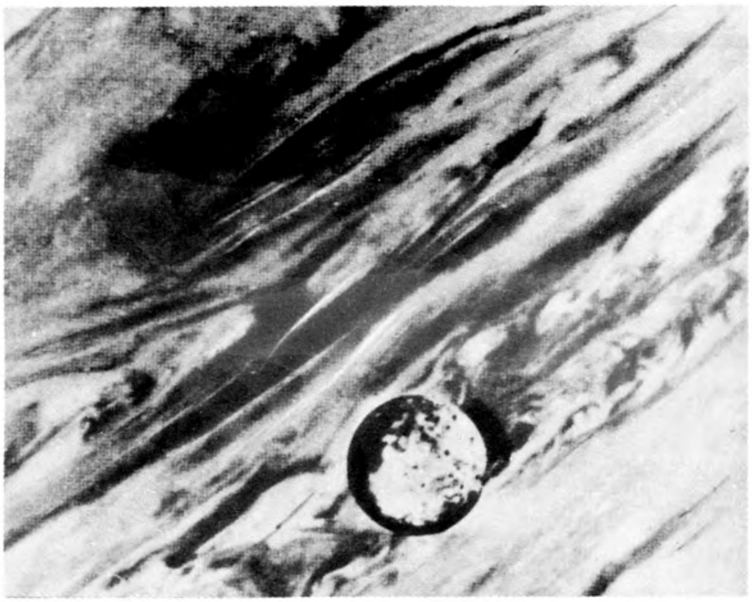

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PRESENTATION OF PAPERS AT THE 30th IAF CONGRESS

Munich, Germany 17-22 September 1979

The Society is anxious to expand the attendance from the U.K. at international space meetings. Prime among these is the 30th IAF Congress, to be held this year in the Deutches Museum, Munich, from 17-22 September 1979.

A wide range of technical sessions will be held, as listed on page 179 of *Spaceflight* for April, as well as many social and other occasions.

The areas in which the Society seeks to stimulate interest are:-

- ★ **The Presentation of Technical Papers.** These are solicited directly by the IAF Programme Committee but members interested in offering contributions are asked to contact the BIS Executive Secretary, who will render all assistance and supply any further information needed.
- ★ **Student Papers.** Papers for presentation at the Student Sessions are dealt with slightly differently in that they have to be submitted to the IAF *via* one of the Member-Societies. Student activity is an area of great IAF interest, so BIS students wishing to participate should do so without delay.
- ★ **Registration as a Participant.** Attendance as a participant is also urged. The report of the previous (Dubrovnik) Congress which appeared in *Spaceflight,* spread over the December 1978-February 1979 issues, provides a good basic account of what to expect. Registration forms and travel brochures are usually supplied by the host-Society from June onwards and will be available from the BIS shortly afterwards.

Members planning to attend the Congress are invited to notify the Executive Secretary.

OUR NEW HEADQUARTERS BUILDING — PROGRESS REPORT – 9

At the time of writing (early March) all the stops are being pulled out to try to complete the main building work on our new H.Q. by 31 March. It will certainly be a cliff-hanger!

The new front door is in place, even the back door, but not the one in between. The basement is being cleared out and the debris occupying the whole of the rear area carted away, ready for resurfacing. Inside, the decorators are going full blast, and with the final touches also being made to hide the remaining wires and pipes. The ceiling rose in the reception area has been hoisted into position and half of the rendering of the outside front facade now completed.

Woodwork and final plastering elsewhere show that good progress is being made in these areas, too, but lagging behind, somewhat sadly, are the members' loos. The roof is on and electricity installed, but none of the essential fittings have yet gone in. Elsewhere, the new light fittings look grand.

Hot news arrived in the shape of planning permission for the Society to display its name and motif (non-illuminated) on the front of the building which, in due course, will relieve the wholesale frustration on the part of the British Rail travellers using the viaduct in telling them, at last, what has been going on.

Security Officers have attended to give advice on safeguarding the Societys' property and have been at pains to point out that whatever one does in this area is not only expensive but absolutely essential. Problems with vagrants and vandals have been reduced since the new protective grilles were installed, but the flank walls have to be raised even higher and more sturdy gates installed. For the rest we must wait and see.

At the other end, so to speak, the problem of "walk-in" thieves appears to be rampant locally so some means of controlling entry must be provided. (For most of our history the front door of 12 Bessborough Gardens invariably remained open, but this was stopped some years ago for the same reason).

The original building contract, now being completed, involved a minimum of decoration but – over the last two months – the Facilities Committee has moved into operation by holding weekly meetings to cope with all the multitude of other tasks what have to be done. The stairs are to be covered, and nosed, louves blinds to be fitted rather than curtains etc. With such a variety of complex detail involved, it is becoming almost impossible to keep track of things. Estimates for this and that rain down like confetti, for all the alternatives have to be explored if we are to make best use of our limited funds.

One formidable obstacle was overcome with the ordering of the Library equipment and the final laying to rest of discussions on layout which have lasted for months. Another vanished when the meetings room chairs were fixed, but there are hundreds of similar other matters in various stages of solution.

Meanwhile, the Bessborough Gardens axe seems about to fall. Discussions with the Crown Estate Commissioners showed quite clearly that their interest in accommodating the Society was still almost non-existent and that they would be glad to see it go right away. In fact, the Secretary almost collected the "Notice to Quit" on the spot, all of which showed that the bullet only just singed our eyebrows, but it would certainly have been a bullseye had we delayed any longer. The Bessborough Gardens we knew and loved, and which has served us so well in the past, will soon be only a shadow of its former self. Road widening schemes, a new street and new office and residential blocks will see to that.

Top of the list of major frustrations is the question of getting a new society telephone – or even only the new number so we can, at least, make a start on getting our new stationery, forms etc. prepared. Not so. The Post Office knows all about such capers. No matter that it has now been going on for over eight months, no matter the multitude of specific promises of dates and times. Top marks to them for holding up progress so completely that "not all the piety nor wit can lure them back to instal half a line."

Added to this will be the requirement for a major clean-up when the builders finally go, then the fitting out marathon and removal, during all of which the Society's work will try to be continued, with the magazines produced, letters answered, callers dealt with and a million and one agonies coped with.

Correspondence intended to reach the Society after 1st May 1979 should be sent to its new address at 27/29 South Lambeth Road, London, SW8 1SZ.

Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

CONTENTS

COVER

CLOSE-UP ON JUPITER. This mosaic of Jupiter has been assembled from nine individual photographs taken through a violet filter by Voyager 1 on 26 February just seven days before closest encounter. The large atmospheric feature below and to right of centre is the Great Red Spot. The complex structure of the cloud formations seen over the entire planet gives some hint of the equally complex motions in the Voyager time-lapse photography. The smallest atmospheric features are some 140 km across. *Bottom left,* This photo of Jupiter's satellite Io was taken on 2 March when the spacecraft was about 8.3 million miles away. Near the centre several round features with dark centres and bright rims are volcanoes. *Bottom right,* Europa, brightest of Jupiter's four Galilean satellites photographed on 2 March from 2.87 million kilometres. Linear markings of the surface are thousands of miles long and up to 50 km wide. Believed to be large fractures or faults, they will be photographed in greater detail by Voyager 2 in July. *NASA*

SPACEFLIGHT

A Publication of The British Interplanetary Society

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MILESTONES

February

28 ESA reports that second qualification firing of second stage of Ariane launch vehicle took place on 23 February at DFVLR test facilities at Hardthausen, Germany. All elements of the stage with Viking 4 engine burning UDMH/N_2O_4 functioned as forecast for 140 seconds. Third stage long-duration test of HM7 lox/hydrogen engine on 26 February at SEP facilities, Vernon, France, was also successful. Test duration was 580 seconds.

March

1 Soviet satellite launched on 21 February by Proton rocket is mistakenly reported in the Western press as a possible "hunter-killer" satellite against geo-stationary targets. In fact it was an Ekran direct-broadcast communications satellite. (*When the first such satellite was launched on 26 October 1976, it was described as an experiment in the direct transmission of a TV programme for viewers in a particular locality, i.e. the region between Novosibibirsk and Irkoust, to the north-west of Mongolia. Ed.*).

3 Second Chinese satellite achieves seventh anniversary in orbit, its radio still operating. Air drag has already reduced its 69.9 degree inclination orbit from the original 268 x 1830 km, 106.2 minute one to 230 x 650 km, 93.4 minutes. Re-entry into the atmosphere will occur this summer.

5 Voyager 1 flies within 277,000 km of Jupiter at 12.42 GMT encountering radiation so intense that one of its measuring instruments had to be switched off. JPL described pictures and data transmitted back as "superb" and said they would be invaluable in analysing the Jovian atmosphere, its giant magnetic field and its bursts of energy that have "the equivalent force of millions of flashes of lightning." Pictures taken at close encounter show features only six kilometres wide. During encounter Voyager flew within 428,000 km of Amalthea, the innermost of Jupiter's 13 known moons. Outbound it photographed the four Galilean moons passing within 20,400 km of Io, 114,400 km of Ganymede, 728,000 km of Europa and 125,000 km of Callisto. Photographs of the moons surpassed anything taken by Earth-based telescopes. They revealed Io to be orange and red with many volcanic caldera; Ganymede to be brown streaked with yellow; Callisto, heavily cratered, darker brown patched with yellow and Europa pale yellow and tan.

5 Section of first Spacelab flight unit to orbit with Space Shuttle 'Columbia' in 1981 leaves Aeritalia plant in Turin *en-route* for ERNO's Bremen factory. It comprises 4 metre diameter cylinder containing benches and floor-mounted racks.

[Continued overleaf

BIS DEVELOPMENT PROGRAMME

SPACE: IMPORTANT POLITICAL & ECONOMIC TRENDS

We are starting a new series in which we invite readers at home and abroad to discuss the political and economic trends which affect the Space Future. As well as acknowledging achievement, we seek to throw light upon areas where opportunities might be lost through want of proper support. Other suitable topics include: the work of government agencies, United Nations' discussions of international aspects of space, understandings signed between governments, significant political and industrial appointments and new contracts placed with industry. Brief notes of up to 750 words will be welcomed. Please address all contributions to: The Executive Secretary, British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ, England.

6 Marconi Space and Defence Systems shows British scientific satellite UK-6 to Press before it leaves for the United States at the end of March. Three main scientific experiments carried are a cosmic ray detector by Bristol University and two X-ray experiments, one for Leicester University College London's Mullard Space Science Laboratory and Birmingham University. Launched by NASA Scout from Wallops Island, Virginia, scheduled 24 May; intended orbit is circular at 600 km inclined at 55 deg to equator.

6 NASA assigns definition and development responsibility for Solar Electric Propulsion Stage (SEPS) to Marshall Space Flight Center, Huntsville, Alabama. First proposed mission is fly-by of Halley's Comet in 1985 followed by rendezvous with comet Tempel 2. Subsequent missions proposed for SEPS include high-energy planetary and Earth orbital missions.

7 NASA announces that nine-month long Space Shuttle ground vibration testing programme at Marshall Space Flight Center, Huntsville, Alabama, "was completed successfully last month." Ground test vehicle 'Enterprise' next will be airlifted by Boeing 747 mother to Kennedy Space Center for mating with External Tank and Solid Rocket Boosters for launch simulation exercise planned for April. Test vehicle will be rolled out from VAB to Launch Complex 39A. Hopefully, roll out of actual flight prototype 'Columbia' will follow in August.

7 Scientists at JPL announce that Voyager 1 has discovered a thin, flat ring of particles about 55,000 km from Jupiter within orbit of innermost moon Amalthea. Ring appears to be about 30 km thick and over 8,000 km across.

7 JPL gives new details of Galileo project which aims to enter a probe into the atmosphere of Jupiter while mothercraft goes into orbit. Attempt will be made to have the orbiter inspect 11 or 13 known moons in turn by choosing a trajectory in which craft will pick up speed gravitationally during each pass of the Jovian satellites. Dr. Bruce Murray explains: "We intend, for the price of one spacecraft, to get information on the atmosphere, a complete mapping of the moons, and understanding of the giant planet's mysterious radiation belts and magnetic fields."

8 Preliminary studies begin at Marshall Space Flight Center "to prepare for increasing the thrusting power of the Space Shuttle by attaching strap-on rocket motors to the Shuttle's Solid Rocket Boosters (SRB's). Additional thrust is necessary to ensure that full Space Shuttle system payload deployment capacity of 32,000 lb (14,515 kg) can be achieved for a 98 deg inclination 150 n. miles circular orbit mission launched from Vandenberg A.F.B., California. First launch expected mid-1984.

8 Space Shuttle 'Columbia' (102) is moved by road from Rockwell International plant at Palmdale to Dryden Flight Research Center, Edwards, California.

9 Voyager 1 observes lightning flashes on dark side of Jupiter extending nearly 20,000 miles (32,190 km).

9 Space Shuttle 'Columbia' being flown piggy back on Boeing 747 carrier from Dryden Flight Research Center sheds section of simulated thermal protective tiles causing partial loss of five or six actual silica glass fibre tiles and slight damage to others. (Some 27,000 of the 34,000 tiles were 'real', the remainder being temporary polyurethane tiles held on by double-back adhesive tape and vulcaniser for ferry purposes. Damage to permanent tiles was caused by tape whipping against side of fuselage and air turbulance caused by absence of simulated tiles immediately ahead of permanent tiles. Polyurethane tiles are to be replaced by actual tiles during flight preparation at Kennedy Space Center, Florida). The problem delays transfer of 'Columbia' to KSC which should have begun the same day.

10 JPL reveals that Jovian moon Io has active volcanoes which have covered large areas with ejecta. Voyager 1 photographs show an active volcano ejecting gases at 1,000-2,000 mph (1,609-3,219 km/h); clouds of ash and particles ascend 93-186 miles (150-300 km) above the surface. Europa is criss-crossed by linear features – major crustal faults – more than 621 miles (1,000 km) long and several hundred kilometres wide. Callisto, heavily cratered, has distinctive 'bullseye' feature probably caused by major impact long ago. Amalthea, Jupiter's innermost satellite, is an irregular body about 100 miles (161 km) long by 80 miles (129 km) wide.

12 Progress 5 is launched at 8.47 (Moscow time) "carrying propellants for Salyut 6's propulsion unit and various other cargoes." Orbit ranges between 191 and 269 km x 51.6 deg to equator; period 88.8 min.

13 *Novosti* reports that cosmonauts on board Salyut 6 are carrying out a full programme of maintenance and repair of the space station which has been in continuous operation for 1½ years. They are paying particular attention to the docking compartments which have been used repeatedly by visiting Soyuz crews and Progress cargo ships. The station's radio and TV systems have been overhauled and extended.

14 Progress 5 docks with Salyut 6 using aft docking port at 10.20 a.m. (Moscow time). Cargo includes UDMH/N_2O_4 propellant, food, water, clothing for work and exercise, a linen drier and "an improved design of the Kristal furnace." Lt. Col. Vladimir Ryumin is reported to have used special zero-g soldering tool which prohibits escape into environment of metallic debris. Final manoeuvre of Progress craft was into orbit of 296 x 324 km under ground control, cosmonauts taking charge of final docking sequence.

14 Reported in Washington that test of the Soviet heavyweight ICBM SS-18 last December released at least 14 re-entry bodies. Under SALT 2, the SS-18 is limited to 10 warheads but four of the re-entry bodies could be decoys.

20 Space Shuttle 'Columbia' is airlifted from Dryden Flight Research Center by Boeing 747 on first leg of two-day, three-stop ferry flight to KST.

24 *Soviet Weekly* reports that USSR Academy of Sciences next year will publish a new scientific journal, *Earth Studies from Space,* under the general editorship of Academician Sidorenko, vice-president of the Academy.

[Continued on page 263

A REVIEW OF BRITISH SPACE PROSPECTS

By P. J. Conchie†

AN INDUSTRIAL VIEW

Contrary to a popular view, U.K. space activity is significant in many ways and continues to stimulate science and industry. Given the political will, the commercial future could be bright. In this article the author gives an up-to-date resume of some of the major developments.

Introduction

Britain does not have the means to launch its own hardware into space so our prospects in this field, apart from the area of essentially ground-based work, depend upon collaboration with Europe and the United States.

British Government funding is largely tied to collaboration of this sort, so Britain's prospects depend on such opportunities as may emerge and our capability to meet them.

In particular, we depend heavily on:

(a) Our ability to meet the technical and managerial challenges of future space programmes.

(b) Our marketing ability.

(c) Lastly, but by no means least, funding.

Flowing through all these factors is the problem which industry and science alike must face, that of plotting a course through the political minefield which increasingly surrounds space programmes.

It is instructive to look back a decade. Ten years ago, *Spaceflight* for February 1968 carried an article headed, "A Space Policy for Britain" which commented on Britain's (then) prospects for space. The article called for, amongst other things:

(a) A European Space Agency; *well, that certainly happened.*

(b) A National Programme; *that certainly didn't happen!*

(c) A European launcher capability; *Yes, but Ariane, not the ELDO vehicle based on Blue Streak.*

(d) A European Communications Satellite Programme; *Yes, that has certainly happened with OTS, ECS and Marecs.*

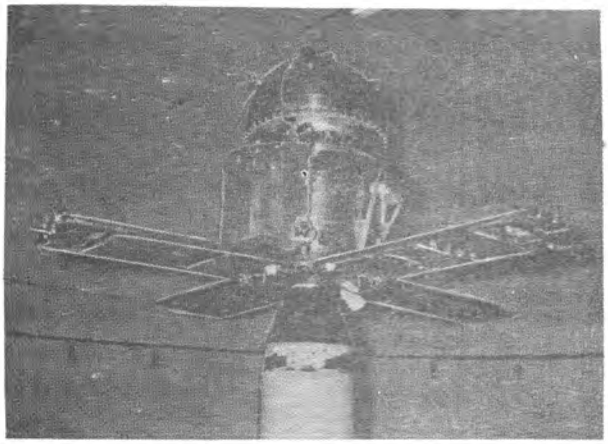
The article concluded as follows:

"Once again the BIS – whose original recommendations for a Euro-Commonwealth communications satellite programme were placed before the (then) Conservative Government in February 1960 – urges the adoption of space programmes which will guarantee an effective contribution by Britain and her European partners. The following lines of action are advocated for UK/European initiatives in space, which amplify previous BIS recommendations to H.M. Governments in the light of events."

* *Based on a paper presented at a meeting of the British Interplanetary Society, Royal Society of Arts, London, 1 December 1978.*

† *Member of Council, British Interplanetary Society. The author wishes to state that the opinions expressed are entirely his own.*

Fig. 1.



UK 6 scientific satellite to be launched this summer by a NASA Scout.

British Aerospace Corporation

Table 1. List of British Satellites.

Scientific	Communications
Ariel 3	Skynet 2
Ariel 4	OTS
Ariel 6	Marecs
UK 6	ECS
ESRO 2	
ESRO 4	
GEOS	
X3	
X4	

Other Spacecraft with British Sub-Systems.

Scientific	Meteorology	Communications
Ariel 1	Nimbus D	Intelsat II
Ariel 2	Nimbus E	Intelsat III
IUE	Nimbus F	Intelsat IV
Heos A1	Nimbus G	Intelsat IV A
Heos A2	Meteosat	Intelsat V
Cos B	Tiros N	Comstar
OAO C		
TD1 A		
I SEE B		
Exosat		

Space Transportation

Spacelab (Pallet)

Ariane (Autopilot,
valves,
release gear, etc.)

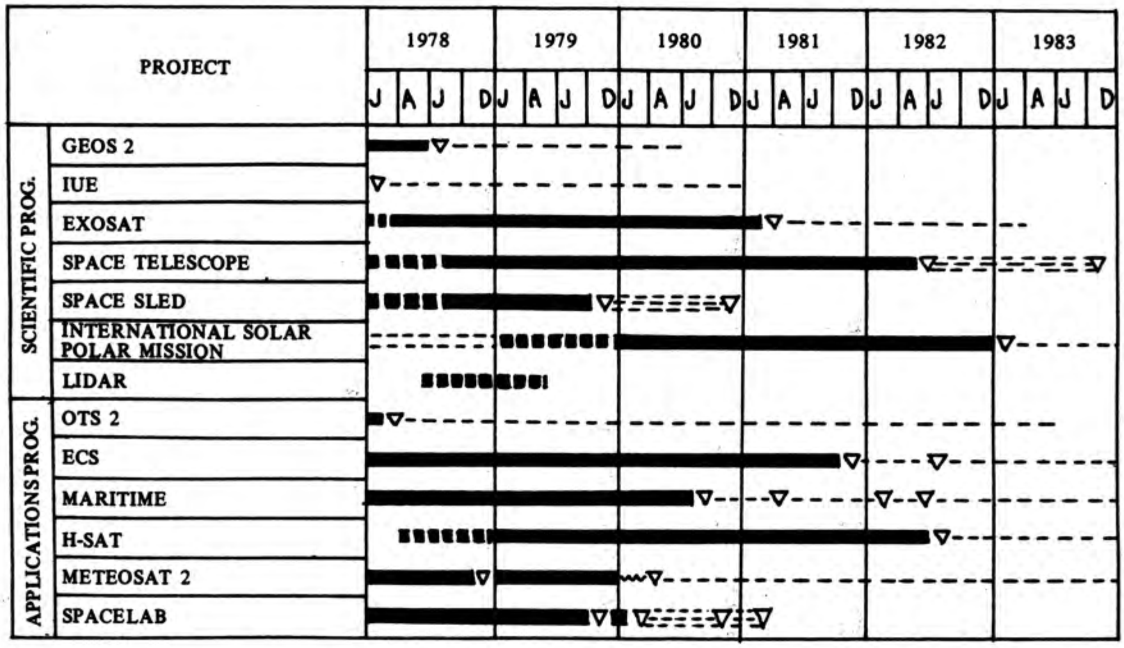


Fig. 2. Programme of the European Space Agency.

If we ask ourselves what has really been achieved since then, we find that a great deal of money has been spent on Spacelab, which did not figure in the 1968 budgets, though there is still doubt that this will prove a worthwhile exercise for Europe: certainly in the UK there appears to be a marked lack of enthusiasm to use Spacelab. UK industry does not appear to see any advantages in processing experiments under low-gravity conditions. Does this mean that a significant opportunity is being lost, or does UK industry regard Spacelab as a luxury?

The Ariane programme is proceeding and achievements to date look good, though whether it will really be justified in the face of the planned low-cost Shuttle launches still remains to be seen.

The lack of a UK National Programme does not appear to have been disastrous, though it might be regretted.

The ESA Comsat programme has borne fruit, with, at last, the successful launch of OTS. Marots came to grief, politically, after technical delays. ECS and Marecs are now running: European 11-14 GHz hardware has been purchased for the ANIK and Intelsat programmes.

So, surprisingly, several of the objectives set forth in 1968 have been realised though the overall impact is, I suspect, far less than was envisaged.

The advantage of Europe having its own launch vehicle, for example, may well be lessened by the need for the USA to secure customers for the Shuttle. Commercial customers are hardly likely to be refused launchings because of competitive, commercial or even political factors.

The success of the Telecom programme may well be muted by the need for continuing technical development.

The establishment of ESA has to be regarded as a positive achievement. It has an international standing and carries out joint programmes with NASA. However, most of those in industry are aware of the vulnerability of their interests in having to rely on ESA for technical support, for the ESA Council is the last place, probably rightly, from which one would expect commercial decisions.

The cost of running the organisation has steadily risen. The extensive test facilities at Nordjwik are not in much use these days: current applications satellites are tested in Germany and at the French facility at Toulouse. The scientific community, particularly in the UK, is increasingly critical of ESA achievements and plans for scientific programmes.

However, UK industry, I believe, enjoys a more consistent funding than it had prior to the formation of ESA.

What has been Achieved

A list of our achievements to date (Table 1) appears most impressive.

- The first UK scientific satellite was Ariel 3, launched on 5 May 1967. (Ariels 1 and 2 were built mainly in the USA, with some UK involvement). Ariel 3 was highly successful.

- The latest in the same series is UK-6 (Fig. 1). British Aerospace, under contract to MSDS, is manufacturing major subsystems. The UK-6 mission will be to undertake investigations in the field of high-energy physics, with three experiments provided by the Universities of Bristol, Leicester and UCL/Birmingham. The satellite will be launched by a Scout rocket in 1979.

- Europe's first scientific satellite ESRO 2 launched May 1968. Highly successful programme led by British Aerospace.

- ESRO IV another successful scientific programme for Ionospheric measurements and particle experiment with British Aerospace as Prime Contractor. A mainly fixed price contract with industrial profit dependent on on-time delivery and performance per day in orbit. Launched 22 November 1972.

- The first British 3-axis stabilised satellite was the technology-proving British Aerospace X4 (Miranda) launched 8 March 1976. Notable for the efficiency with which the programme was managed. A totally fixed price contract with the Prime Contractor answerable to a very small expert team in the Department of Trade and Industry with the assistance of RAE.

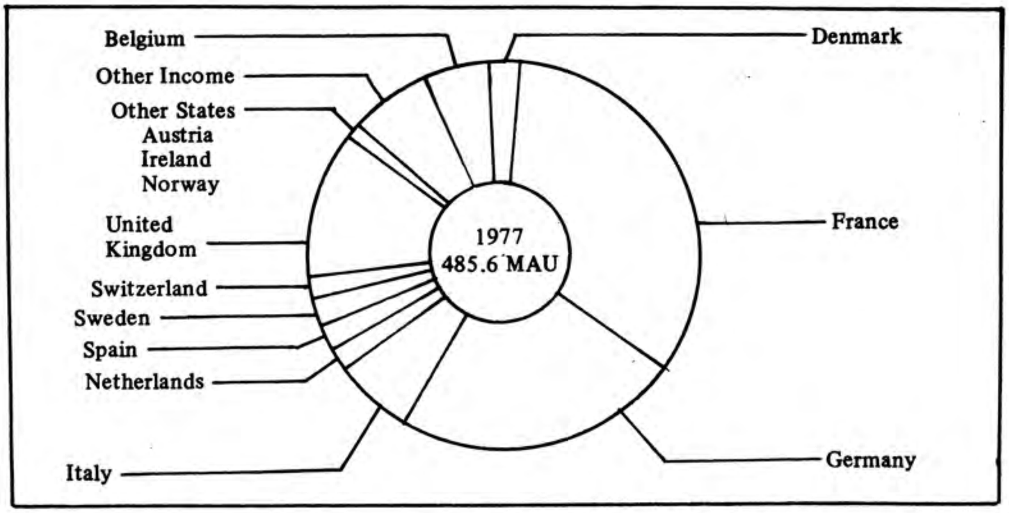


Fig. 3. ESA Contributions.

- As a member of the STAR consortium under contract to Dornier Systems, British Aerospace supplied subsystems for the ISEE-B satellite in the NASA/ESA International Sun-Earth Explorer System. These included the attitude and orbit control subsystem sensors, hinged booms, control electronics and reaction jet system and the satellite's mechanical ground support equipment. The satellite was launched in October 1977 and is still operating satisfactorily.

- As a member of the MESA Consortium under contract to Matra, British Aerospace supplied subsystems to TDI, Europe's first 3-axis stabilised satellite. Also British Aerospace was responsible for the ultra-violet telescope of this very successful scientific satellite.

- GEOS 2, Europe's first geostationary scientific satellite, successfully entered its orbit on 14 July 1978, and is now operational. The satellite was developed for ESA by the STAR Consortium led by British Aerospace at Bristol.

GEOS 1 was launched on 20 April 1977 but, due to a fault in the launch vehicle, the satellite entered a twelve-hour elliptical orbit rather than the intended geostationary orbit. It has since completed a thorough study of the morning and afternoon sectors of the magnetosphere and has demonstrated that the novel onboard experiments are able to measure plasma densities, electric fields and ion compositions in ranges and with a precision not previously possible.

GEOS 2 recently suffered slight damage in collision with a meteorite which shorted one of its solar cells to the body of the satellite. The problem has, however, been overcome and GEOS 2 continues to provide large quantities of new scientific information.

Skylark

Significant improvements have been made in the performance of this highly successful upper atmosphere research rocket by the introduction of new rocket motors which enabled British Aerospace to offer a capability across the whole spectrum of sounding rocket research. The most recent version, Skylark 12, can lift 140 kg (300 lb) to an altitude of 800 km (500 miles). To date, 375 Skylarks have been launched from ranges around the world.

- Skylarks are at present being used in the German TEXUS programme for research into problems of materials processing in space.

- British Aerospace was involved in the Intelsat 3 programme and built six of the Intelsat 4 satellites, as well as six Intelsat 4A and four Comstar satellites which were similar in shape. The company was responsible for structure, solar arrays, battery packs, wiring harness, RCS and nutation dampers.

- MSDS, with Ford Aerospace, were responsible for the U.K. national military communication programme Skynet.

- The U.K. has been since 1974 responsible for the ESA Telecommunications Satellite Programme with British Aerospace responsible for the OTS satellite and now the ECS and Marecs satellites and MSDS the L band payload of the Marots now Marecs Maritime communication satellite.

These advanced 3-axis stabilised satellites utilising the basic concept to meet various communications missions at minimum costs, represent Europe's hopes to exploit its investment in applications satellites by securing outside sales. Summarising our assets then:

(a) We have demonstrated the capability to produce satellites in the applications and scientific fields and indicated a particular experience in the communications satellite field, in high-power arrays and in solid state transponders with the MSDS work at 1.5 GHz.

(b) The nationalisation of Hawker Siddeley Dynamics and British Aircraft Corporation has provided a single company which now represents the major share of UK industrial expertise in space, which should, therefore, be in a strong position to obtain a share of the European Space Budget. Britain's contribution is about 30 million pounds so we could expect to get 40% back, perhaps more if ESA can find ways of reducing its internal costs.

The current ESA programme is shown in Fig. 2. The contribution by member states is shown in Fig. 3.

ESA is, I believe, approaching a crossroads in its policies. All of the main programmes – the ones covering the major share of funds if one ignores ESA's own costs – are past their peak funding point. For example, Spacelab, the really big spender ($698 million at 1978 prices) is past its peak, as is Ariane. The Telecoms programme is in the process of moving into the operational phase of ECS, with Interim

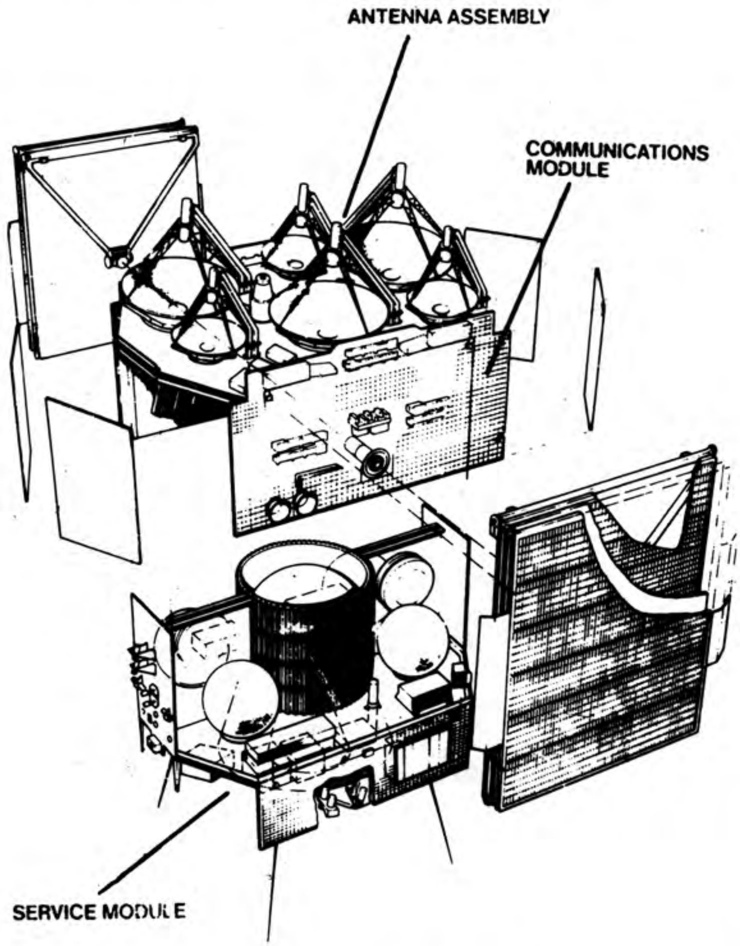


Fig. 4. European Communications Satellite (ECS).

Eutelsat, increasingly, taking over financial responsibility.

The result is that, assuming that the future budget level is fixed at around 400 million AK, significant sums should become available from 1980 onwards for new programmes.

What *will* this money be spent on, or what *should* it be spent on? Should the UK decrease its contribution and start a National Programme, similar to those of France, Germany and Italy?

Previous UK National Programmes have been successful and efficient. The X4 (Miranda) programme, for instance, as already mentioned, was run by a particularly small team in the Ministry and RAE. On the other hand, political decisions could, and did, turn the taps on and off for some programmes – not very good for industrial planning.

National Programmes are not necessarily more efficient, for we can see, in Germany and France for example, decisions being made on the basis of the share to be given to a particular company or region, and not based solely on efficiency or lowest cost. ESA does provide the basis for continuing funding, but at a cost, with a 40% return quoted.

It is clear from this that the top priority for ESA should be to reduce its in-house costs and to undertake only those tasks for which it is most suited. Those tasks which could best be done by national establishments should be done by them: those which can best be done by industry should be done by them. It is certainly right and desirable for ESA to support industry, yet not be expected nor allowed, to enter wholly commercial areas.

National funding should be available:

(1) To support developments required to achieve the potential to exploit commercial opportunities.

(2) Support developments necessary to enable UK groups to undertake programmes which are prestigious for the UK, i.e. to produce the key elements in NASA or ESA programmes.

It is interesting to speculate, in the field of commercial Comsats for example, that if 10% of the UK contribution to ESA had been paid directly to industry to enable it to undercut US competition, this would probably represent the best use of UK money to secure a prestigious and profitable programme. The peripheral activities that a Prime Contractor for a Comsat programme could expect would form an important opportunity for exploitation by UK industry.

Near-Term Opportunities

In the near-term, our opportunities lie in:

1. Comsats.
2. The Space Shuttle.
3. Scientific areas.

Comsats represent a tremendous opportunity. British Aerospace, as prime contractor for ECS and Marecs and with OTS behind it, is in a position now to break into the commercial Comsat market, though no-one should underestimate the task. British Aerospace has been working on the market since 1974, with Cable and Wireless as a close associate. It is on the bidding list for the League of Arab States programme (Arabsat), for the Australian programme and for the 2nd generation Indonesian programme.

The basis for its interest lies in ECS. This is a 2nd generation OTS (Fig. 4), scheduled to provide communications links for the European PTT's and EBU and, in Marecs form, a world-wide maritime communications system.

The modular concept of OTS has been largely retained, thus enabling various payload requirements to be accommodated within the same service module elements. Antennae coverage has to be carefully arranged, not only to conserve radiated power but also because of the potential interference problem with other Comsats as orbital positions become more crowded.

The basic service requirements for regional Comsats are set out in Table 2.

ECS has to be, and is, compatible with the Thor-Delta 3914, the Space Shuttle and Ariane.

It is clear that, to break into this market, British Aerospace would need:

1. To meet technical and financial requirements.
2. To have total Government support, preferably from European Governments as well and certainly from France and Germany.

Both will, no doubt, prove difficult to achieve. For example, the involvement of European companies is essential to achieve support from their governments, but many companies distributed throughout Europe making small items does not give a cheap product. Compatibility with the Ariane launcher will probably also be essential though this may not really prove to be the cheapest nor even the optimum launcher.

The transponder poses another problem for, although Europe pioneered the 11-14 GHz band, it is not the optimum for third world applications and although the 2.5 GHz transponder, for community broadcast, could come from the UK, the 4/6 GHz transponder will probably have to come from the United States.

The next launch phase will involve either the Shuttle or Ariane: a spacecraft optimised for the Shuttle may not be optimum for Ariane – it may not even fit within the Ariane heat shield. In addition, many potential customers will be looking for 24 channels of 4/6 GHz transponders working at the same frequency, with polarisation diversity, plus a

Table 2. Trunk telephony and data with national or regional coverage.

Trunk Services	4/6 GHz transponders typically 10W output
Community Services	2.5 GHz transponders typically 50W output
Thin link routes between small ground stations	
Television distribution network	
Community TV distribution to low cost ground stations	

community TV broadcast capability. Certainly, if one wishes to optimise the use of the Shuttle for a geostationary orbit, one does not want one motor (ABM) placed on top of the other (perigee kick), though, for Shuttle launch, both are needed (Fig. 5).

Looking further ahead, it is generally agreed that multi-beam SSTDMA operations at 11/14 GHz and 30/20 GHz will be the next step in providing additional capacity. ECS has a capacity of 18,000 voice channels and the Intelsat project, for 1985, around 100,000. The reasonably achievable capacity for the next generation Regiosat would be in the 75,000 region, with a growth capability of several times this and a videophone capacity of around 2,000 duplex channels. Spot beam ground coverage capability should be such that coverage to individual countries in Europe can be provided, with coverage of specific regions a future possibility.

The ultimate requirement must be for a broadcast capability to individual homes using household antennae of around one metre diameter. For this, the satellite would need to have a capability of up to 36 channels in narrow beams.

The Scandinavian Nordsat requirement (8/5 channels in two beams) must be regarded as a minimum requirement. The interim step of TV distribution should be included, though this would involve the transmission of up to 36 TV programmes to regional stations of 2-5 m diameter, for local distribution by cable or local transmitter.

A general view of what the 3rd generation British Aerospace Comsat could look like appears in Fig. 6. It would have integral Perigee and Apogee motors and roll out of the Shuttle bay. These remarks indicate, only too well,

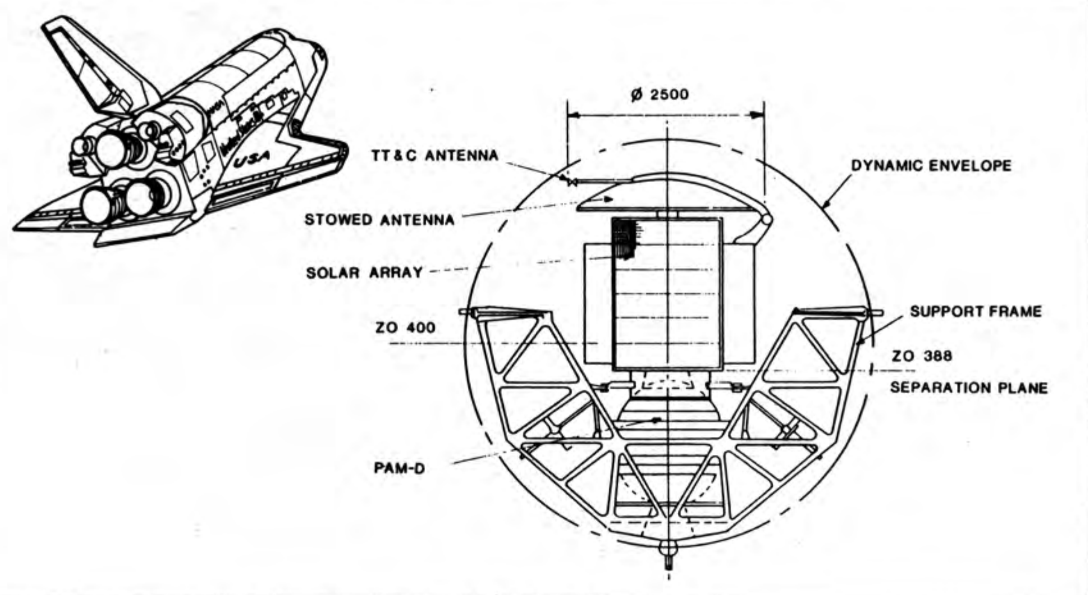


Fig. 5. Shuttle launch Plan D, showing the launch configuration in which the antenna reflector is laid over the top of the satellite.

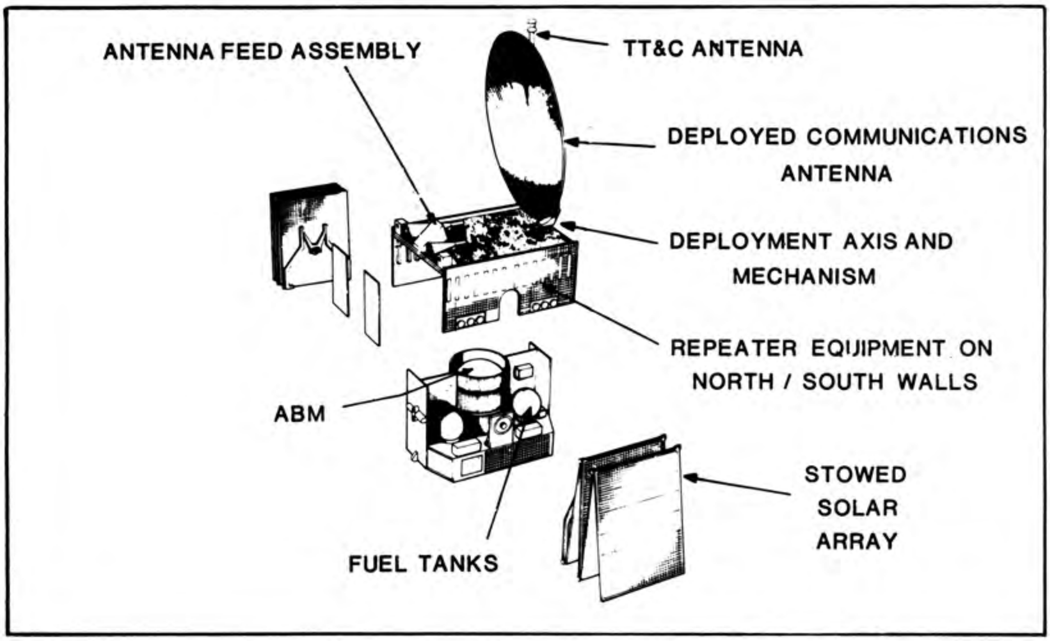


Fig. 6. Satellite construction with the antenna reflector upright.

that to obtain a chance for the next generation of Comsats will require substantial investment and it is unlikely that ESA can fund it in the probable timescale for many reasons, not least because Ariane and H-sat will be competing for funds.

Funding, therefore, will probably have to come from industry, perhaps helped by some national funding to initiate task developments.

Spacelab

A second opportunity area must be Spacelab.

As already observed, UK industry appears to see little scope in manufacturing, etc., in the low-gravity environment, certainly to judge from their current lack of interest in the Spacelab experimental programme. Germany, on the other hand, has planned several industrial experiments so we shall soon discover whether we are missing out or whether the German view is coloured by the availability of ready-Government funding. Those branches of science previously interested in experiments in space appear to see little of value in Spacelab, owing to its limited orbit and observation time.

The most interesting UK potential arising from the Spacelab and the Shuttle are the pallet and the large arrays of the space telescope, in both of which British Aerospace has a significant role.

British Aerospace are developing for ESA a lightweight hybrid solar array (LHSA) which will be capable of providing 6 kW of power at the end of a seven year lifetime (Fig.7).

The array is a flexible fold-out array for satellites which require a nominal power in transfer orbit (up to 200 W, supplied by a small rigid panel) and full operational power in geostationary operational orbit. Additionally, studies have been made of 25 kW (Fig. 8) and a 5 MegW for Space Solar Power Systems.

Scientific Satellites

The third area of opportunity is that of scientific satellites. Until recently, the scientific programme was the central core of UK industrial activity in space. Now, the budget is around 75.5 million AK, whereas the pre-'71 level would be equivalent to 100 MAK in 1978. But more than that, ESA is concentrating on larger programmes, which mean less experimenting, fewer satellites and, perhaps surprisingly, a less meaningful programme for the average interested observer. Even if we could not really understand the value, e.g., of some of the X-ray work, one was made aware of the intense interest in the topic in UK scientific circles. Obviously, with fewer papers published and fewer experiments, the programmes will have less and less impact.

Our first requirement in the UK is for a coordinated scientific space policy, the second for a more integrated approach. At present we have the SRC, DoI, MoD, etc., all pulling in slightly different directions, unlike CNES (France) or DFVLR (Germany).

Space science is important for its own right. The scientists involved have to feel that they are getting somewhere and the man in the street must also feel that it has some meaning for him, too, i.e. be prestigious.

What about our prospects in this area?

(a) *Exocet* has little UK involvement.

(b) *The Space Telescope* (Fig.9) has Lockheed as Prime Contractor. The telescope, with a primary mirror of 2.4 metres (7.8 ft) in diameter will be placed in near-Earth orbit at 500 km (311 miles) where it will be able to detect objects 50 times fainter and seven times further away than those seen with telescopes on Earth. A faint object

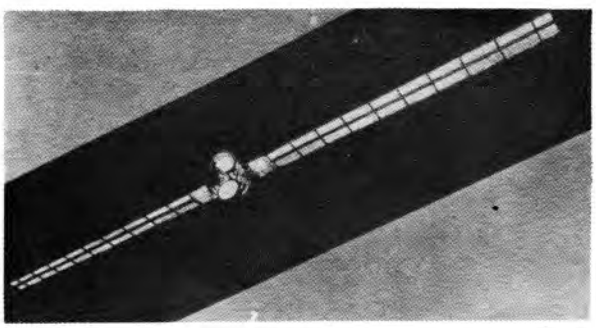
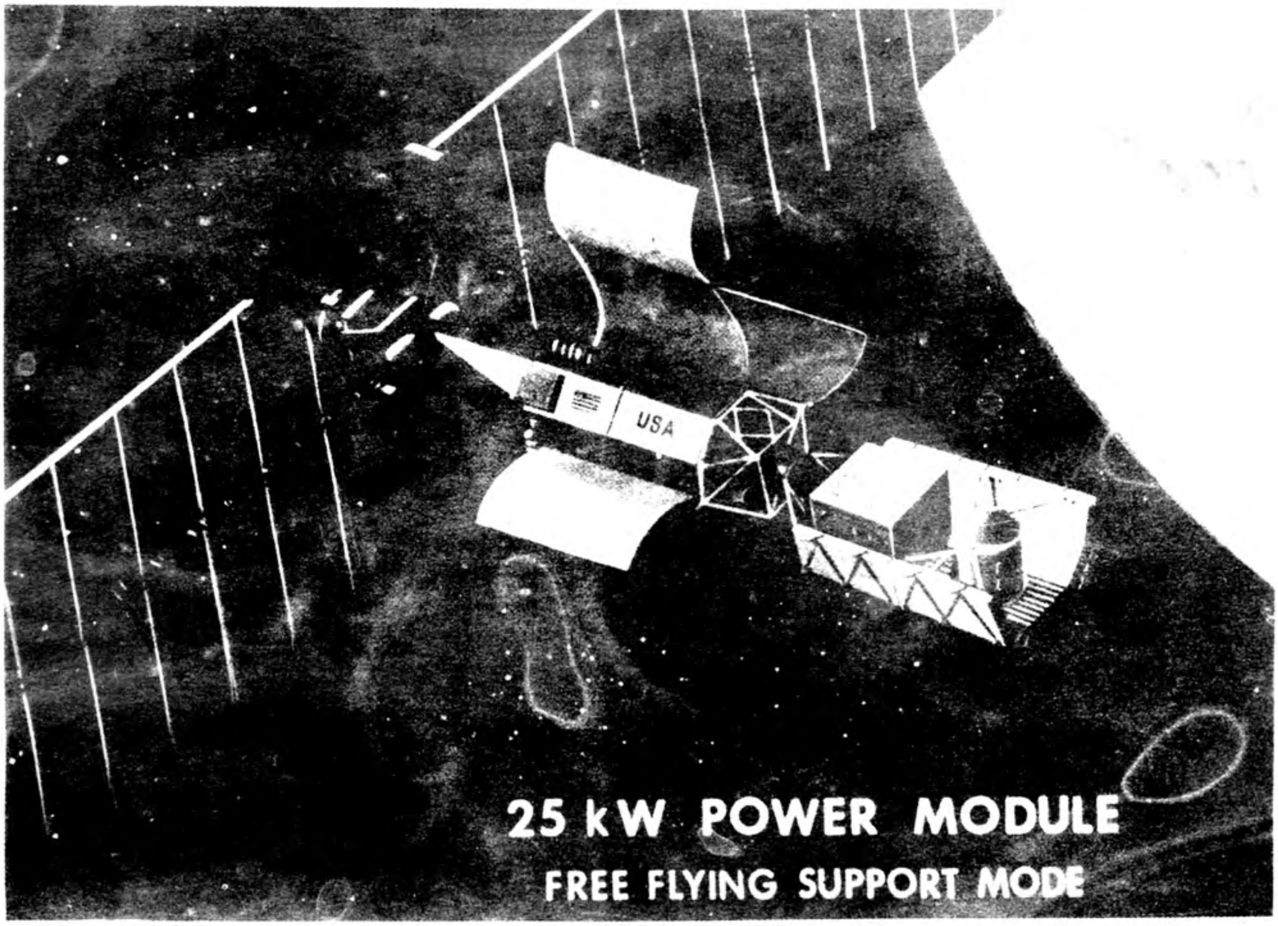


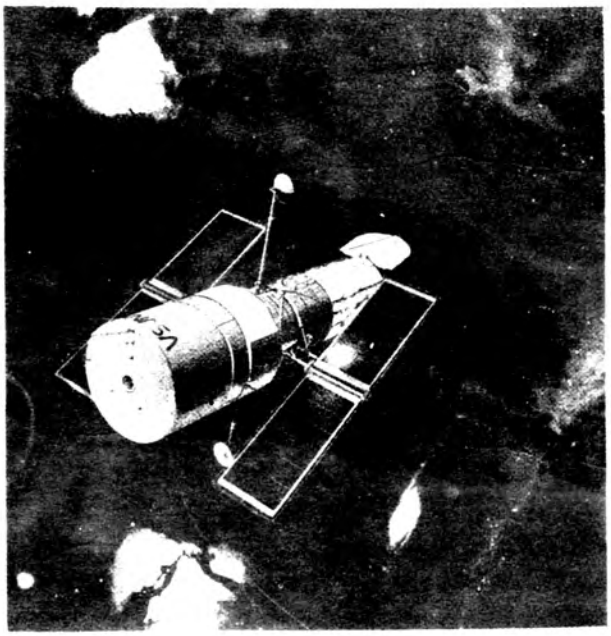
Fig. 7. Hybrid array 6 kW.

Fig. 8.



Above, 25 kW Power Module: Free-flying Support mode.

Below, Fig. 9. Space Telescope.



camera will be used to detect and record images of celestial objects so faint that the pictures are to be built up by counting the individual photons of light arriving at the focal plane of the telescope. The camera will focus these photons on to the Photon Detector Assembly, to be built by British Aerospace, which will amplify the light until their position can be recorded by a low-light level TV camera tube.

The signal from the camera tube will be analysed by a complex electronic pattern recognition logic unit to build up the image of the star.

(c) *Space Telescope Solar Array.* British Aerospace Dynamics Group is the Prime Contractor to ESA for the development and manufacture of the solar arrays. Fully extended, the solar array will comprise two identical deployable and retractable solar panels employing a double roll-out flexible substrate upon which the solar cells will be mounted.

The deployed arrays will be 12 m long and have a total area of approximately 50 m². They will carry some 50,000 silicon solar cells and will deliver in excess of 4 kW of power at 34 V after two years in orbit. Each wing can be deployed, retracted and orientated independently.

The solar arrays are being designed to meet the requirements of Astronaut in-orbit maintenance and contingency operation and the arrays are therefore unique in this respect, in Europe.

The Future

Beyond this, there are the multi-mission spacecraft. At

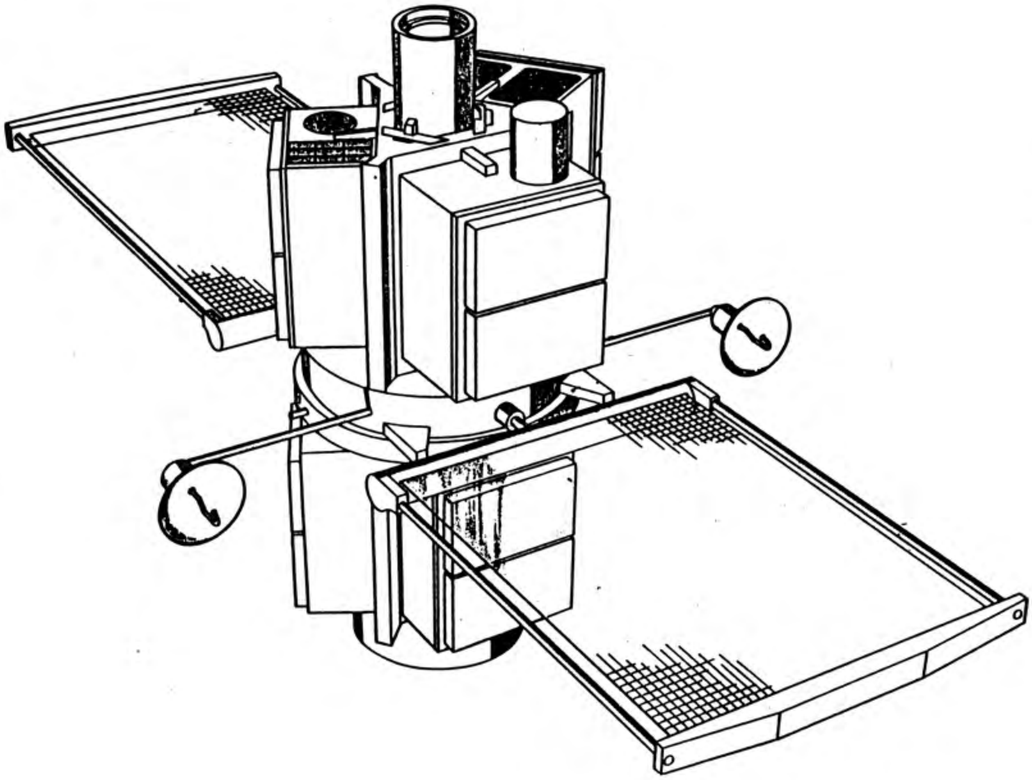


Fig. 10. Multi-mission Service (MMS) – twin – with Science Research Council payload. USA 1.

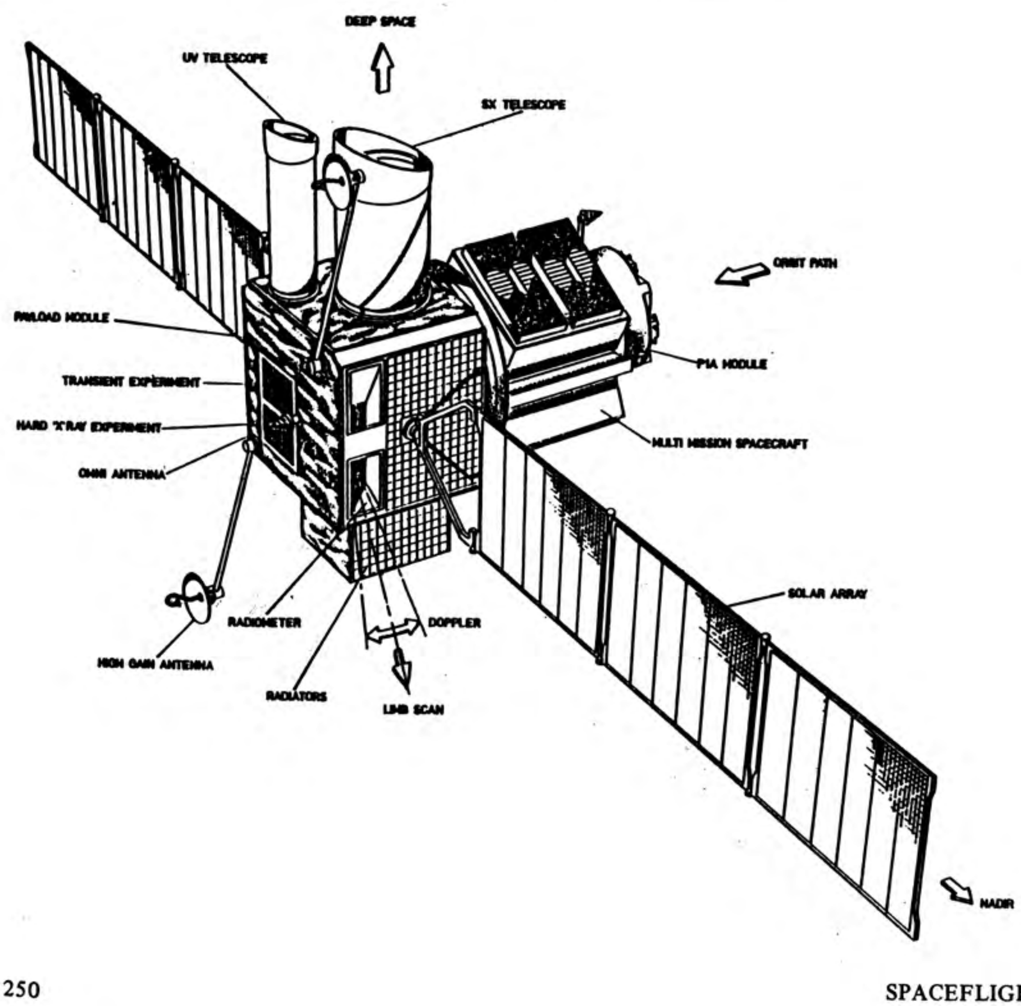
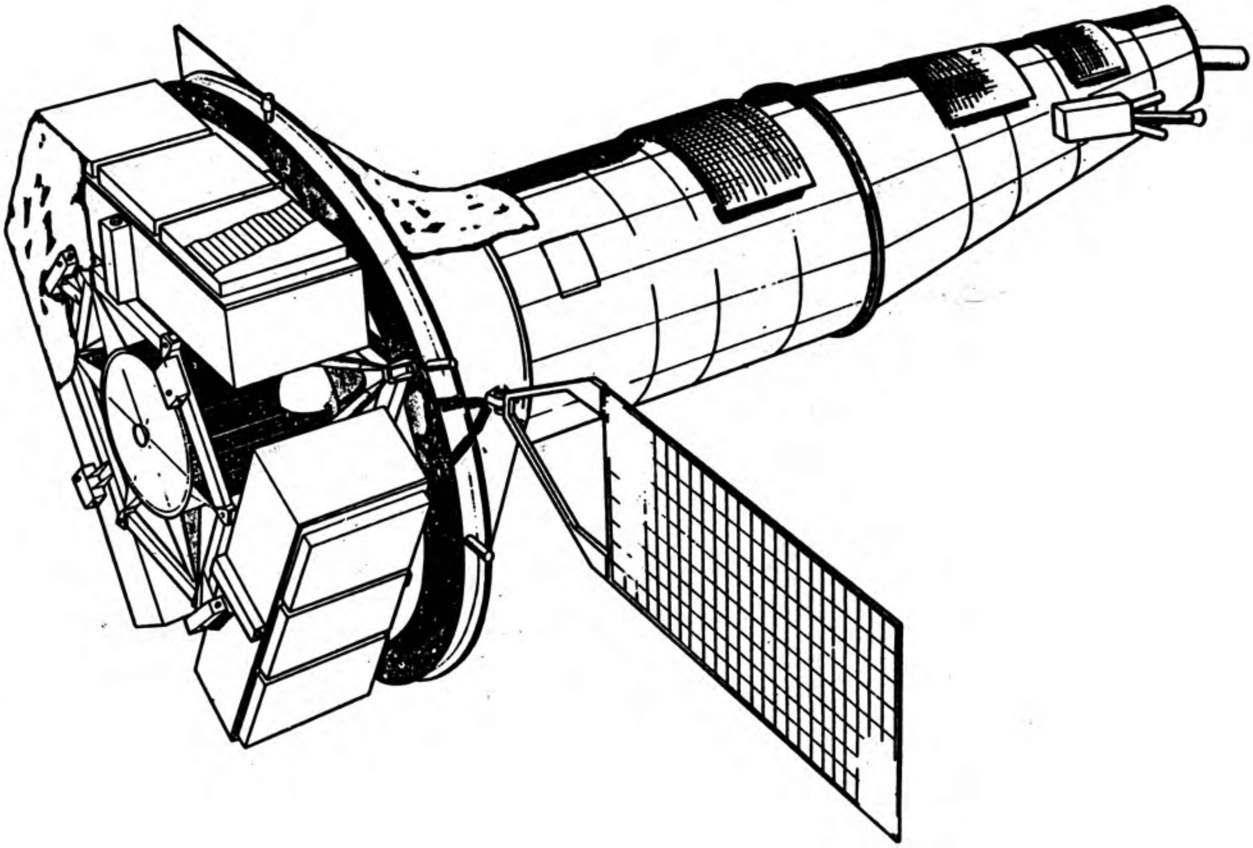


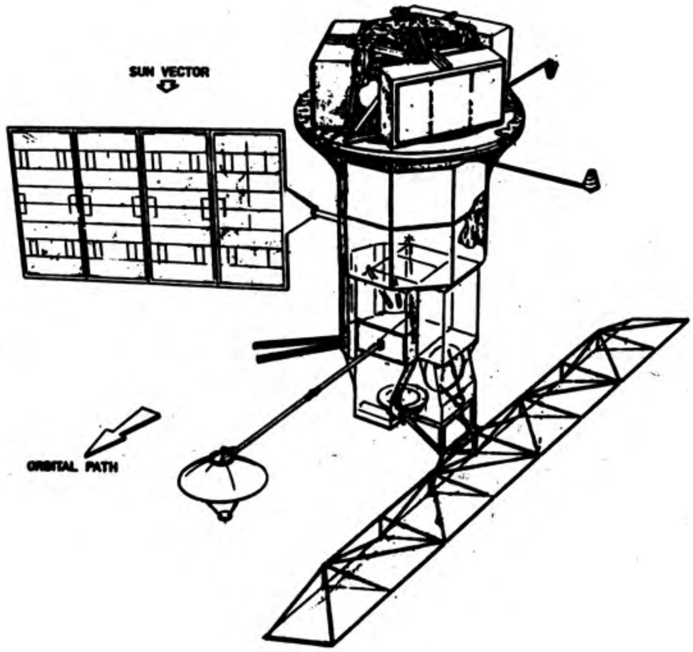
Fig. 11. MMS with transverse SRC payload. USA 2.



Above, Fig. 12. UK/MMS – payload grazing incidence solar telescope (GRIST) UK 1.

Right, Fig. 13. Ocean monitoring payload on UK/E MMS Bus. UK 2.

All illustrations British Aerospace Corporation



present the SRC seems bent on a collaborative deal with NASA.

An example of such a mission appears in (Fig. 10). This shows a dedicated astronomy mission, with all sensors pointing at the same source, either X-ray, UV or high energy. The lower half is the NASA multi-mission service module with the experiment in common in the upper half. Experiments are interchangeable in orbit.

Figure 11 shows a multi-discipline approach.

Whilst all such ventures are difficult, it seems to indicate an excellent opportunity for Europe to produce its own MMS.

Such an example appears in Fig. 12, with the payload to the right of the solar panels. An Earth resource variant is indicated in Fig. 13.

Planetary Exploration

I would hope to see a UK initiative on the question of Mars or Mercury exploitation. In 1976 I attended a meeting of the Southern California Branch of the BIS where two lectures were presented on Mars exploration. I have always felt this to represent an area of the greatest scientific interest and have a major impact for the "man in the street".

There are several proposals concerned with Mars in which we could participate. One contemplates an orbiting spacecraft with probes put on the surface and below it, with telemetry up to the orbiter. The UK could, at least, manage a probe.

Another proposal could involve bringing back a sample. Quite apart from the engineering, the scope of the tests necessary to be carried out on the sample during the journey in order to ensure no contamination of this planet would be considerable.

Such test concepts and achievements are one excellent example which would provide stimulating and farsighted work for a UK space project.

Discussion

During the interesting discussion which followed the presentation of this paper, the following subjects were included.

(a) Employment activities in space on which the author stated that he understood that there were many vacancies in the space industry in the UK.

(b) Whether the Confederation of British Industry should seek to evaluate the Space Shuttle development as they might affect their constituent members – generally agreed as desirable.

(c) How space projects came about.

(d) Future power supplies from space.

(e) The cost effectiveness of international collaboration.

MANNED MANOEUVRING UNIT

By Dave Dooling

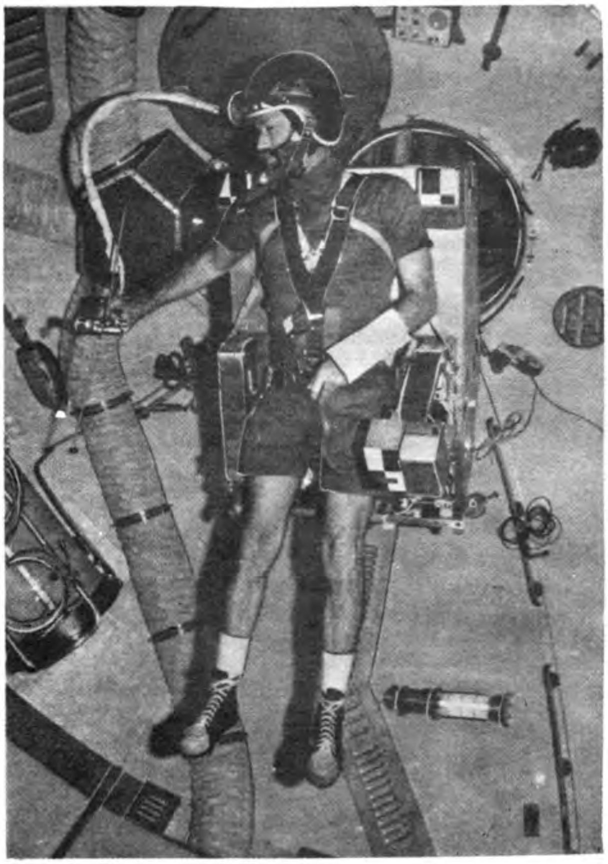
Introduction

Space walks will take on a Buck Rogers air around 1982 when Space Shuttle astronauts start using a manned manoeuvring unit (MMU) that will allow them to rocket (slowly) to and from other spacecraft.

The MMU is the result of a two-decade effort to develop a simple way for astronauts to fly during extravehicular activity (EVA). It has a simple, highly reliable design that should satisfy most EVA requirements.

The simple design is a direct result of exhaustion. In 1965, the first EVAs by Alexei Leonov of the USSR and Ed White of the USA were deceptively simple. They floated about, had a grand time, and pronounced walking weightless to be effortless, just as pulp science fiction had predicted.

But later EVA during Gemini saw the astronauts tire rapidly when they tried to do real work. Weightlessness, in addition to being fun, also eliminates the friction that we need to keep everything in place while working. One nudge, and the astronaut starts to drift. Even putting on the astronaut manoeuvring unit (Edwin Aldrin, Gemini 9) in the style of donning a backpack proved to be nearly impossible.



SKYLAB astronaut Gerald Carr, commander of the Skylab 4 mission, flies the astronaut manoeuvring equipment of the M 509 experiment in the forward compartment of the Orbital Workshop during the last manned mission.

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Skylab Experiments

Skylab (1973-74) proved to be the "ideal dynamics laboratory" for studying EVA, according to Major Ed. Whitsett (USAF), manager of the MMU project at Johnson Space Center in Houston, Texas. The upper level of the Skylab workshop was 20 ft (6.1 m) high and almost as wide, providing room to test a model backpack indoors.

The backpack was designated experiment M509. It was not an idealised MMU. Its thrusters were powered by an unrechargeable nitrogen bottle, and its rate control computer was not very advanced.

But it worked so well that even crewmen who had not trained on it were able to fly acceptably. Manoeuvring was easy, and films show astronauts carrying off-centre loads or flying in circles. They were able to recover quickly if tumbled by another crewman, or to pick up and stabilise another crewman who was tumbling.

In 14 hours of tests – nine in a spacesuit – five astronauts exceeded all goals, and not once bumped into the workshop wall. (The limiting factor on tests, oddly, was the gas exhausted by the thrusters: gas composition and pressure in Skylab had to be adjusted to compensate after a long test.)

From this success, Whitsett, astronaut Bruce McCandless, and others have been developing the MMU for the Shuttle programme.

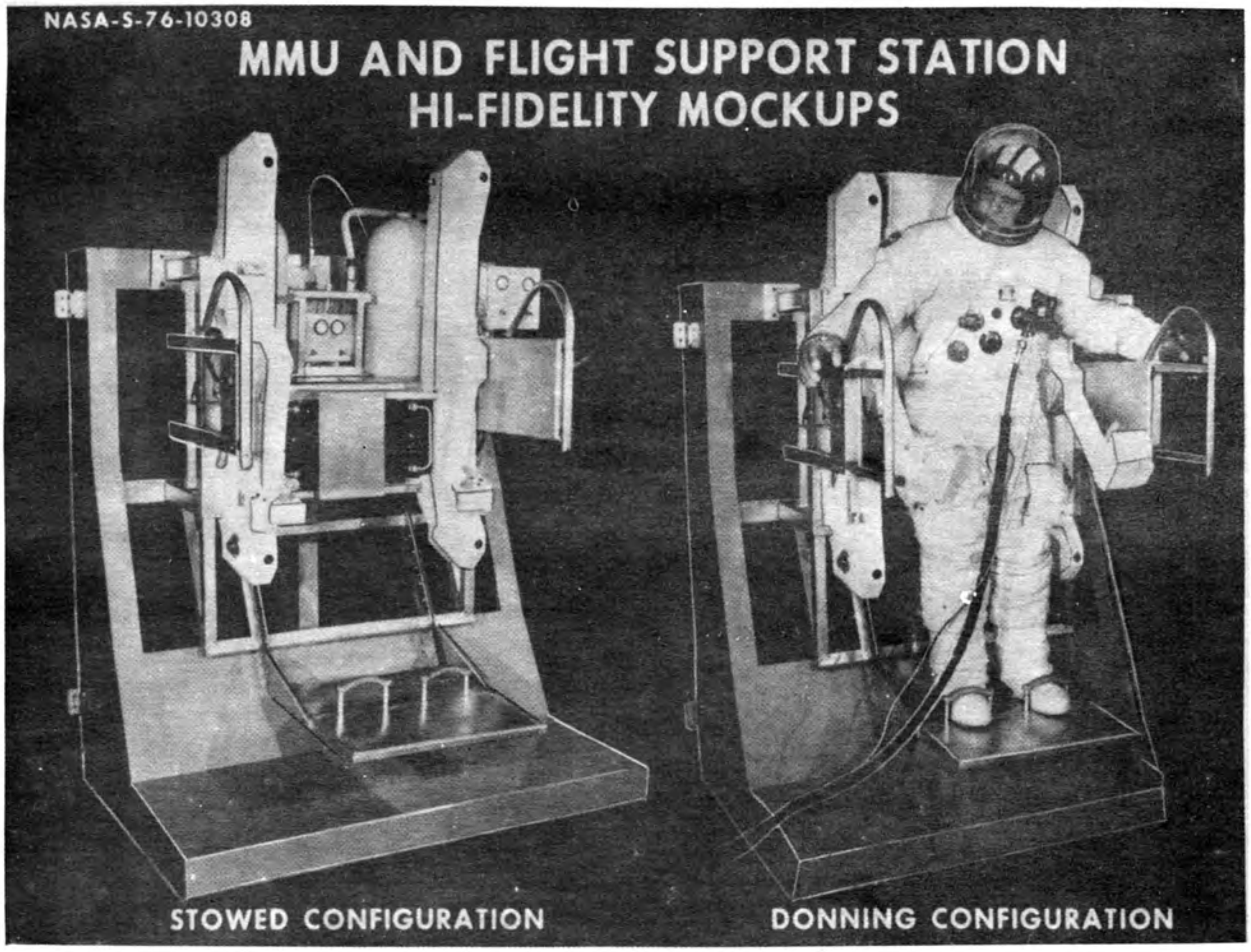
"Basically, we regard it as a very useful means of getting from point A to point B," McCandless said. He expects the scientific community to become enthusiastic as they learn that payloads, such as the Space Telescope, can be designed for easy maintenance in space without getting the Shuttle too close.

The MMU will weigh 243 lb (110 kg). It more closely resembles a diving backpack: its design is dominated by a pair of large nitrogen gas bottles. Mounted between the bottles are the control electronics assembly.

For EVA with the MMU, the astronaut will wear the standard EVA mobility unit (EMU, see *Spaceflight*). To recap, the EMU is different from previous space suits. The torso section is a rigid aluminium shell with arms. The lower section runs from waist to feet, and is attached by a large slip ring to the torso section. Gloves and helmet attach much the same as on earlier suits. The life support unit – with oxygen, batteries, and cooling – is permanently attached to the back. A status panel and emergency oxygen are mounted on the chest.

After donning the EMU, the astronaut passes through the orbiter airlock into the payload bay. The MMU is in a flight service station mounted near the hinge of the payload bay doors and just aft of the cabin bulkhead.

To don, the astronaut simply backs into the MMU. Two



MANNED MANOEUVRING UNIT and flight support station.

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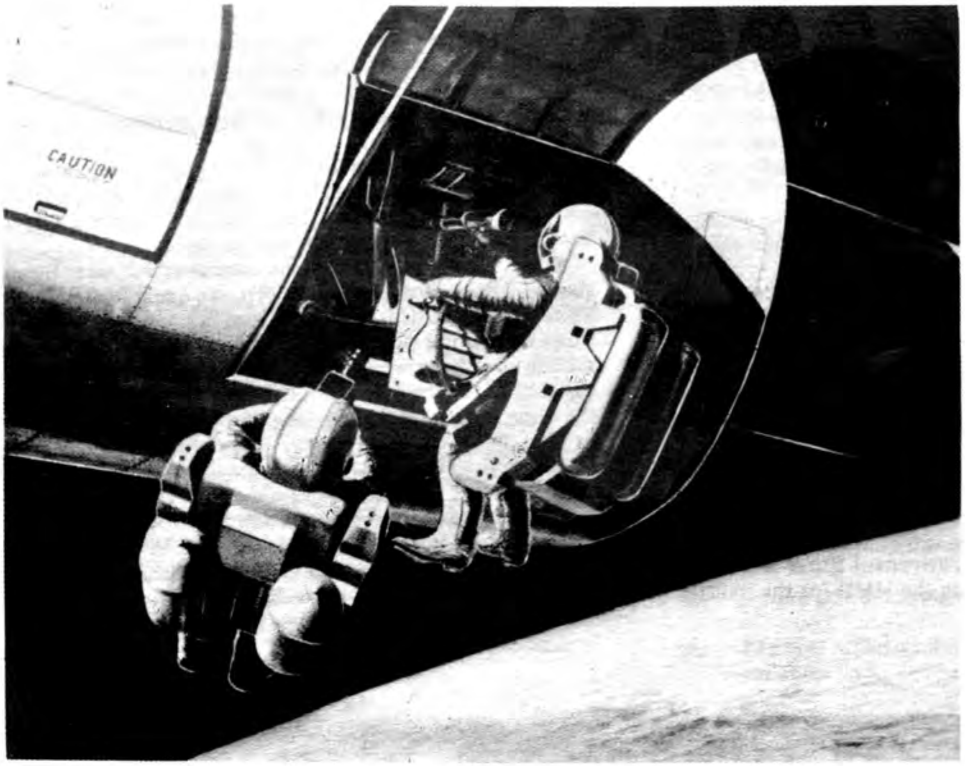

EXTRAVEHICULAR WORK SYSTEMS – REPAIR ACTIVITY. Orbital technicians are shown repairing a 'beam builder' using on-site repair aids. Such activity will become commonplace with the advent of the Space Shuttle. The technicians are equipped with EVA mobility units (space suits and backpacks) and manned manoeuvring units for transportation.

National Aeronautics and Space Administration

latches on the MMU clasp the EMU. There are no electrical or fluid hook-ups, a major problem in early EVA. MMU status is transmitted to the EMU panel by a light-emitting diode on the MMU that faces a photocell on the EMU.

The only other connections are the two hand controllers. When ready, the astronaut releases capture latches on the flight service station and flies away. The procedure requires no assistance and takes less than 10 minutes.

The right hand controls rotation (10° per sec²) and the left hand controls translation (0.3 fps²). The MMU control system has three rate gyros, and can be programmed to maintain a set attitude (+0.5°) so the astronaut can use his hands, or the translation can be controlled through direct and rate command modes. The system is divided in half so that if part fails, full control can be maintained by shutting down the half that has failed. When the thrusters fire, the astronaut is given an audio tone through the headset; other audio tones signal low gas or power.

The MMU is propelled by 24 cold-gas thrusters, each with a thrust of 1.4 lb (0.63 kg) (the AMU on Gemini 9 used hydrazine, requiring the crewman to wear steel mesh "hot pants" to protect his spacesuit). Although the thrust is low, it is enough to move the MMU and astronaut out to 300 ft (91.4 m), loiter, and return. The cold gas also permits the astronaut to work with spacecraft that have optics that might be contaminated.

The range is limited to 300 ft (91.4 m) because of orbital mechanics. Beyond that distance, the astronaut must go through increasingly complex course corrections, just as any spacecraft must for rendezvous. It also keeps the astronaut in a position to easily gauge his range without radar, and easily return to the orbiter.

After a mission lasting up to six hours, the astronaut parks the MMU in the flight station, disengages himself and returns to the airlock. The batteries and nitrogen bottles are recharged from orbiter supplies.

The MMU will not, at least after final flight testing, be attached to the orbiter by a tether. Neither will it have a remote control system for the orbiter crew to return a disabled astronaut. Whitsett said that automatic controls would complicate a design that has been kept simple, deliberately.

"It's kind of unusual in this kind of business," he said, "in that we have a system that is better from a crew point of view and is also simpler from an engineering point of view." Additional features are work lights, window-washer-style strap attachments, and two auxiliary power outlets, and acquisition lights.

First Shuttle Tests

The first MMUs are not scheduled to fly until the second Shuttle orbiter (OV-099) is available. Until then early EVA will be with astronauts tethered to the orbiter.

McCandless said that Johnson engineers are starting preliminary studies of additional EVA gear, including a more powerful "space scooter" that would carry astronauts and equipment farther, and modified handheld police radar units have been demonstrated to provide the sort of range and rate data needed for operating beyond the 300 ft (91.4 m) limit.

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FOUR-PLANET METEOROLOGY

Introduction

All the planets with atmospheres have common characteristics which are helpful in understanding weather and climate on Earth, reports the National Aeronautics and Space Administration. Return of the first data about Mars, Venus and Jupiter's atmospheres has begun a major enlargement in the scope of the atmosphere sciences. Scientists now have examples from four planets instead of just one. Missions devoted primarily to planetary atmospheres, of which Pioneer Venus was the first, should help considerably.

Scientists emphasise that in studying Earth the first place to look at is the Earth. However, useful insights into the behaviour of the Earth's atmosphere can come from general planetary meteorology, and data from other planets provides an additional, valuable research tool.

Specific similarities to Earth's atmosphere exist on the other planets. These include Earth-like cold fronts on Mars and Earth-like high cloud layers on Venus. But scientists think the most significant findings from extraterrestrial atmospheres may lie in an improved general understanding of atmospheric circulation and climate. Such results may well be more important for understanding Earth's multi-year weather cycles than for shorter term forecasting. Since various of man's activities currently appear to have potential for altering weather cycles, such understanding is important.

The Earth has had important climate changes in time periods meaningful to man, over decades and hundreds of years. Some examples with major economic consequences are the droughts in the American West every 22 years; recent destruction of the Sahel and expansion of the Sahara desert in Africa, and effects of the Little Ice Age from 1450 to 1915 on agriculture in the Northern Hemisphere.

Mars, Venus and Jupiter

For the terrestrial planets (Earth, Mars and Venus), the main determinants of climate are: (1) changes in the Sun's output; (2) changes in orbits and axial tilts; (3) gas and dust content of the atmospheres; (4) land surface characteristics; (5) reservoirs of volatiles, and (6) outgassing of material from planet interiors. For nonterrestrial planets, Jupiter and Saturn, it is necessary to add an internal heat source.

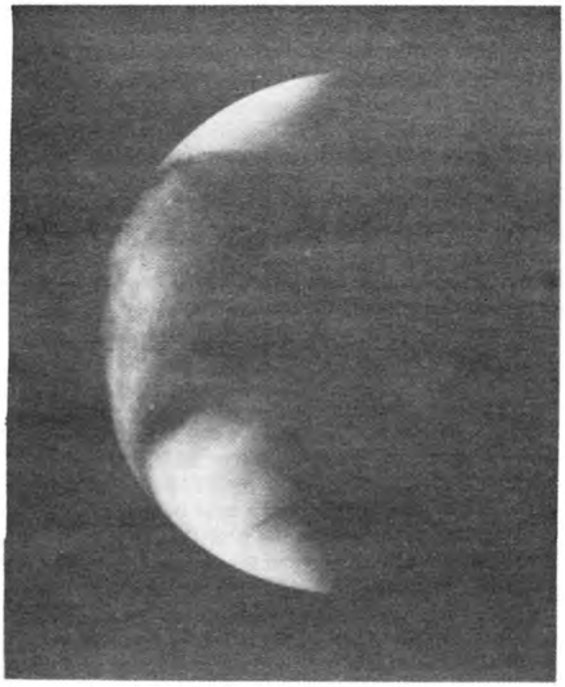
Of the two other terrestrial planets, Mars seems to display the most Earth-like characteristics. It has the same length day. Its axial tilt is similar, giving it similar seasons. It appears to have circulation patterns like the Earth's cyclones. However, these seem to occur only in the winter hemisphere. In much of the summer hemisphere, the Earth-like prevailing westerlies turn into easterlies.

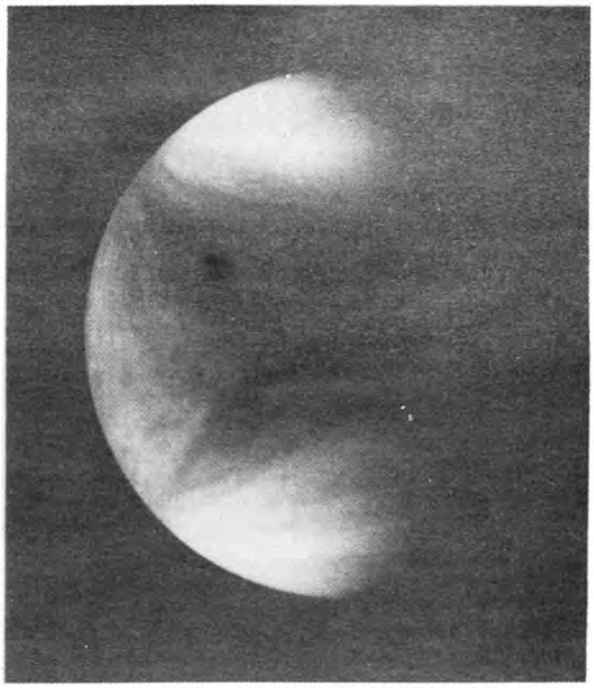
The big differences in Mars weather are thought to be the major role of the planet's carbon dioxide atmosphere – and the role of heat-absorbing dust.

The condensation of Mars' carbon dioxide atmosphere into ice at the pole of the winter hemisphere means that there is a steady flow of the 95 per cent carbon dioxide atmosphere to the winter pole, where it freezes. The polar region constantly and evenly sucks in new atmosphere to replace that frozen out.

This continuous flow, and permanent low pressure zone at the winter pole, apparently has planet-wide effects in both winter and summer hemispheres because it alters the atmospheric pressure and affects large-scale winds. The poleward flow direction reverses twice each Martian year, with Martian winter and summer.

Dust on Mars seems to have some of the heat-transferring characteristics of water vapour on Earth. The feedback





VEILED PLANET. The image of Venus at left was acquired by the imaging experiment on NASA's Pioneer Venus 1 spacecraft on Christmas Day 1978 at about the time the landing module of the Soviet spacecraft Venera 11 parachuted through the atmosphere. Based on preliminary estimates provided by the Soviets for the time and location of the entry probe, the Russian craft should have descended along the equator near the planetary limb (leftmost edge of image). This area is within the arms of a dark horizontal Y-shaped feature which stretches around much of the planet. Clouds in this region form cellular patterns suggestive of convective activity in the atmosphere.

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mechanism of the Martian Great Dust Storms may control climate on a global scale and shows some parallels to the water cycle on the Earth. The "tidal" flow of the thin Martian atmosphere appears to be due to big, local solar heating effects resulting from heat absorption by dust. (Temperatures rise 10-20°C in a few hours.) The atmosphere expands rapidly from the heated local noon point, creating 20 mph (32 km/h) winds. As the local noon point moves rapidly over the Martian surface, these winds ebb and flow like sea and land breezes. In Mars' mid-latitudes, the winds also are channelled by Mars' high mountain ridges, producing strong boundary flows. In the equatorial regions, sun-warmed mountains provide "heat islands" in the atmosphere. These tidal winds, the mountain-range channelling, and the elevated heat sources in the atmosphere provided by mountains also exist on Earth, but the best examples are on Mars.

Venus, on the other hand has atmosphere motions and characteristics far different from those of Earth. Its atmosphere is 100 times as massive as Earth's and temperature at the surface is 900°F. Sluggish winds in the almost liquid atmosphere at the surface are 1-2 mph (0.6-1.2 km/h), while at the clouds tops, around 37 miles (60 km) altitude, the winds blow at 200 mph (321 km/h). Venus' climate is believed to be the result of a "runaway greenhouse effect" in which solar heat is trapped easily – but only reradiated with great difficulty.

For purposes of comparative meteorology, Venus appears to be valuable because it seems to be a simple weather machine. Its major atmosphere motions appear to be global. Heat distribution over the planet appears to be almost completely uniform at all points. This means that the many observations of the six spacecraft of Pioneer Venus may well be able to provide a good characterisation of Venus' atmosphere circulation, composition and structure in one combined operation.

Atmosphere scientists have great interest in a radically different planet like Venus because they view the other planets as weather laboratories. The mathematical models describing behaviour of the Earth's atmosphere frequently fail to account for all the atmosphere motions. So scientists want, where feasible, to test out the same kinds of relationships under extreme conditions – with different gases and under very different temperatures and pressures. As one researcher puts it, "If a theory seems to work on two or three planets, it's probably right."

A completely gaseous, giant planet, Jupiter, also can help. Jupiter's atmosphere, driven by internal heat, flows round-and-round the planet, showing the same general patterns for years at a time. This is due to the giant planet's rapid rotation, and the long relaxation times of its atmosphere gases. Jupiter's many hurricane-like features appear to be similar to Earth hurricanes, and like those on Earth, to be driven by the heat of water vapour condensation. However, since no direct atmosphere measurements have been made and the amount of water vapour is unknown this will have to remain conjecture until the Galileo mission sends a probe into the atmosphere. Close-up Pioneer Jupiter photos of Jupiter's clouds show other circulation patterns that appear to be Earth-like.

Earth's Weather Cycles

In addition to several already mentioned, the Earth has had various other climatic changes which are a result of planetary weather cycles. These have been, and will be again, of great importance to man. The most recent ice age ended long ago, about 12,000 years ago. But this means that the current warm, ice-free period has already lasted about as long as the typical lengths of interglacial periods in the last million years. The onset of past ice ages has been known in at least one instance to take as little as 100 years, though onset is usually gradual.

Ice ages, obviously, are due to climatic cooling, and a decline of as little as 1°C in the average global temperature would affect northern region agriculture. It has been suggested that a one-degree temperature drop might endanger the Canadian wheat crop.

The most recent major temperature decline occurred during the Little Ice Age, 1450 to 1915. In England during this cold epoch, the Thames River froze over so thickly that fires were built on the ice to roast oxen for ice fairs. Today, the Thames almost never freezes. The Norse colony in Greenland, established centuries before, perished in this period because of packice in the North Atlantic and the disappearance of most agriculture there due to cold.

The best evidence suggests that the Little Ice Age was due to an almost continuous series of huge volcanic eruptions in those years (Tambora, 1815; Krakatoa, 1883; Pele, 1902 etc.), combined with some other factor, perhaps a short-term variation in solar heat output. These volcanic eruptions injected volcanic gases into the stratosphere, which turned into heat-reflecting sulphuric acid droplets, blocking solar heating.

Interestingly, these sulphuric acid droplets, scientists believe, are identical to droplets in the clouds of Venus. These droplets have major effects on Venus' climate. We need to consider that industrial pollution produces acid droplets like the Venerian and volcano-injected droplets, and a build-up in the lower atmosphere could cause important, though probably less dramatic climate change.

The Little Ice Age was followed by a period of warming in the northern hemisphere for 55 years (a 1.1°C increase in average temperature) and then a 20-year period of cooling in the 1950s and 60s, .6°C, which shortened by two weeks the English growing season.

Cooling also affects rainfall. During the colder portion of the last 100 years in Northwest India, there were more years having abnormally low rainfall than in the warmer years. Some researchers suggest that dust from mechanised agriculture, like that generated in the dust storms of the 1930s also may have produced relatively local atmosphere cooling.

It has been suggested that the flood widely reported in the Bible and other early writings was due to the abrupt ending of the last ice age 10,000 years ago, with a consequent rapid rise in sea level. At its maximum, the last ice age – the Wisconsin – lowered sea level 100 metres. Today, even after the ocean rise to "normal", there is enough ice locked in Antarctica and Greenland to raise the oceans another 100 metres from present levels.

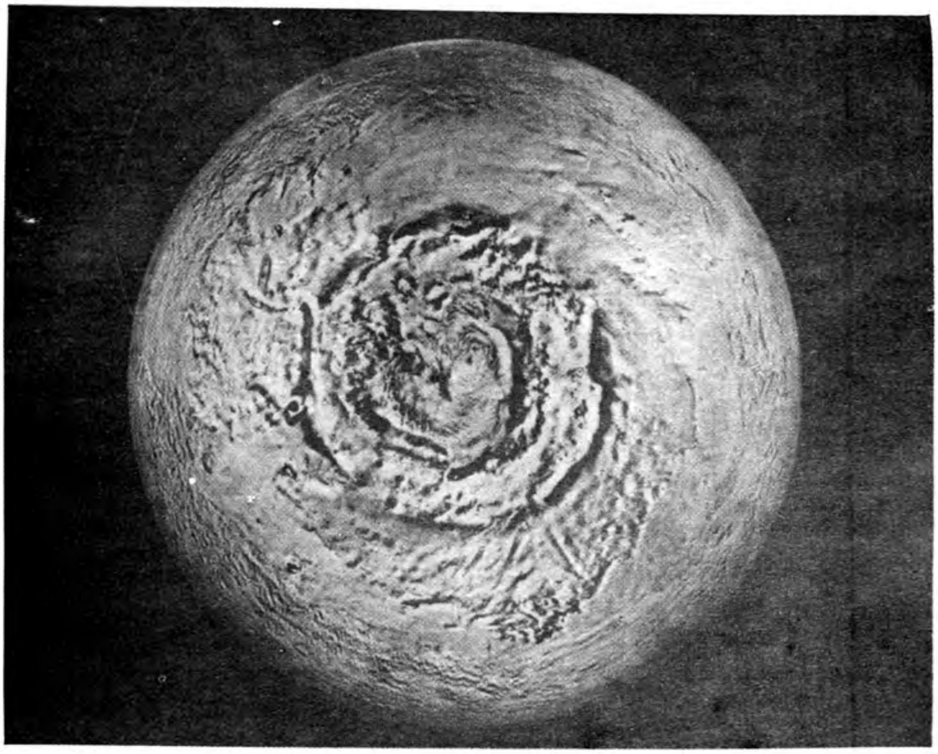
Venerian phenomena can be related to these Earthly ice/water ratios. Venus' hell-like climate and atmosphere is thought to be due to a runaway greenhouse effect, where large amounts of solar heat are retained, and only reradiated with difficulty.

The Venerian greenhouse is due to trapping of heat by atmospheric carbon dioxide, and if Venus ever had any water, by atmospheric water vapour as well. (Today the sulphuric acid clouds, believed to have appeared later in the evolution of the atmosphere, add a kind of lid to further hold the heat in, superheating the Venerian air).

At present rates of increase in the burning of fossil fuels, we are adding to the Earth's atmospheric carbon dioxide at a rapid rate, with several researchers predicting a doubling in the amount by the year 2050. This might well increase the Earth's greenhouse effect, and hence its average temperature. This would probably be a relatively minor effect (about 1°C increase in average global temperature). But it might be enough to melt portions of the Antarctic and Greenland ice caps – enough perhaps to cause major permanent flooding of coastal cities.

Atmospheric dust may have an important, though probably secondary role on Earth. On Mars, atmospheric dust seems to be a primemover. The Great Dust Storms on Mars,

THE RED PLANET. This global mosaic of Mars, 4 ft (1.2 m) in diameter, is made of more than 1,500 computer corrected television pictures taken by the U.S. Mariner 9 in 1971 and 1972. The residual North Pole ice cap is at the centre. It is the first photo globe ever made of any body in the Solar System and was prepared by the Jet Propulsion Laboratory which managed the Mariner project for NASA.



Planetary Comparisons

Planet	Surface Pressure In Earth Atmospheres	Average Surface Temp. in °F	Atmospheric Constituents	
			Major	Minor
Venus	90	900°	CO_2	HC1, HF CO, H_2O, Ar
Earth	1	80°	N_2, O_2 A	CO_2, H_2O O_3, etc.
Mars	.006	45°	CO_2	O_2, H_2O CO

Planet	Cloud Cover	Surface Conditions	Direction change in Poleward flow due to Coriolis (at 30° Latitude)	% of Atmosphere below high Topography	Length Of Day
Venus	100%	Chemical: Equilibrium	3°/day	20%	117.6 Earth days
Earth	50%	Liquid	14.4°/hr	30%	24 hrs.
Mars	5%	Dusty	14.4°/hr	60%	24.6 hrs.

Planet	Time for atmosphere to return to former state after local heat input: By Radiation	By Atmosphere Circulation	Temperature Decrease From Surface °F/Mile
Venus	31.7 years	8.3 hrs	34°F
Earth	116 days	50 min	23°F
Mars	2.3 days	83 min	5°F

during which the whole planet is obscured by dust, radically change the planet's atmospheric temperature structure because the atmospheric dust absorbs solar heat directly.

Mars' atmosphere always seems to have much more suspended dust than the Earth's – on the average about 10 times as much as the amount above a large city on a smoggy day.

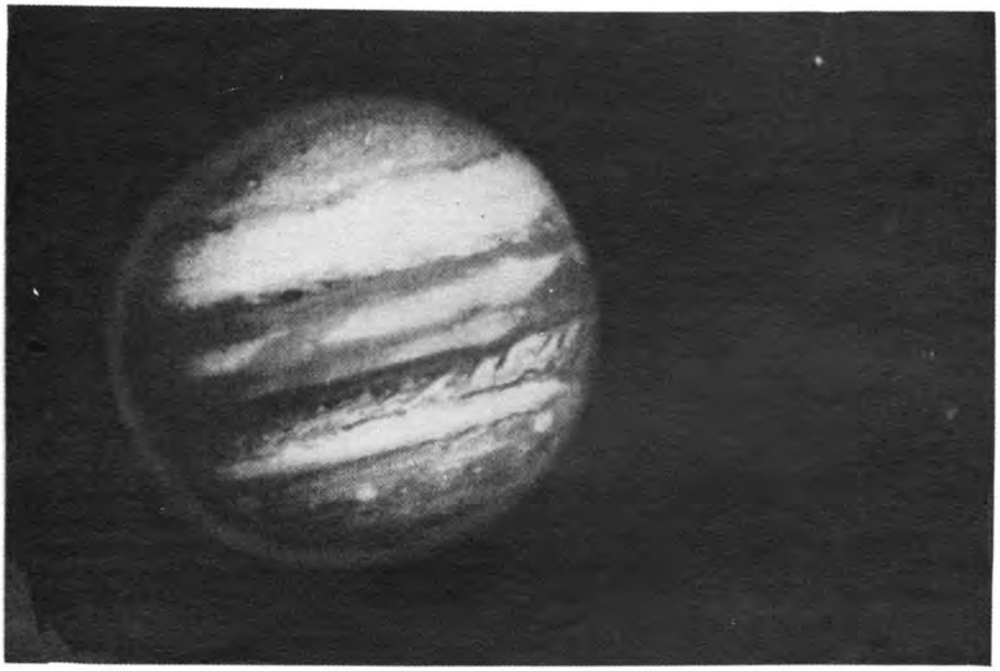
Heat absorption by dust can raise atmosphere temperature on Mars as much as 25°C in one day. This generates winds, and as more dust is pumped up into the atmosphere, more heating occurs, until the whole planet is veiled in dust. This process may be in some ways analogous to the energy build-up in tropical hurricanes, but the water vapour in Earth's atmosphere disappears as it rains out, keeping hurricanes local. Martian dust and its effects may stay aloft planet-wide for months.

Other effects also related to surface conditions seem to have occurred on Earth in the Sahel region of Africa. There overgrazing reduced planet cover and made the surface more reflective of solar heat, thus cooling it. This cooling reduced upward motion of the atmosphere and the amount of rain. The resulting drought further reduced planet cover and made the drought even more serious.

Planetary Weather Laboratories

Further examples of the planets as weather laboratories where the same phenomenon can be studied in different locations, are these:

1. There is substantial evidence for correlations of 11 and 22 year cycles of solar storm activity with Earth's weather cycles. For several hundred years, there have been droughts somewhere in the American West every 22 years. These correlations to solar storms also appear to operate over much shorter periods. They may be due to a triggering mechanism, it has been suggested by a number of scientists. Recently, Dr. Ralph Markson of MIT, and other groups at University of California, Berkeley, Johns Hopkins and elsewhere, reported the findings of a relationship between these weather cycles and incoming high energy solar and cosmic ray particles. The atmosphere can be thought of as an electric generator and these particles now



JUPITER. Voyager 1's cameras captured two of Jupiter's moons, Ganymede (right centre) and Europa (top right) in this picture taken on 17 January 1979 from a distance of 47 million kilometres. Scientists at JPL observed rapid changes in Jupiter's atmosphere, some occurring within 20 hours (two Jovian days). An example is changes in the long series of wave-like patterns trailing Jupiter's Great Red Spot. The bright zone stretching across the northern hemisphere may be clouds of frozen ammonia similar to cirrus clouds of water ice in Earth's atmosphere.

seem to be able to alter atmosphere conductivity and change thunderstorm patterns. Thunderstorms are major distributors of energy in the atmosphere. There are 1,500 of them, on the average, raging somewhere in the world at any given time. Understanding the effects of solar storms on Venus, Mars and Jupiter's atmospheres may help with understanding these relationships on Earth.

2. The Venus weather machine is believed a simple one because the planet has no axial tilt; hence no seasons. It has almost no rotation and hence lacks short day-night cycles, as well as the *coriolis* forces which rotate Earth cyclones. It lacks the oceans which store and transport much of the Earth's heat. Its cloud cover is planet-wide, eliminating the effects of cloud and clear areas. The mountainous relief of its surface areas mapped so far appears to be lower than Earth's and much lower than the dramatic Martian uplands and mountains.

   Like Earth's, Venus' climate is believed to have evolved and changed radically. Venus is in several ways identical to Earth, and is often called our twin planet. Calculations suggest that if Earth were only six million miles closer to the Sun, it, like Venus, would have had a runaway greenhouse effect. With this terrific heating, Earth's atmosphere would now be as massive as Venus', 100 times as dense as it now is – like being under 3,300 ft (1,005 m) of water. Such heating would boil out all the carbon and oxygen from the Earth's calcium carbonate rocks, vapourise the water of the oceans and most other volatiles.

   If Venus had no greenhouse effect, the planet, which is 26 million miles closer to the Sun than Earth, would be hotter than Earth. (About twice as much solar heat arrives at Venus as at Earth). But its polar regions would have habitable temperatures. Scientists believe that Venus' greater solar heating progressively forced the planet's volatiles into the atmosphere and the intensifying greenhouse effect made it hotter and hotter. The sulphuric acid clouds further intensified the greenhouse effect, adding still more heat to the Venerian pressure cooker.

3. Earth-like Mars with its 24-hour rotation and day-night cycles, a relatively clear atmosphere, and tilt on its axis (seasons), also shows climate change. There is evidence of running water (the numerous dried up river beds of today's Martian landscapes). The liquid water which flowed on Mars in the past is thought to have been due to:

   - Outgassing of the planet from volcanos, which produced a thicker atmosphere. Like Earth's before life appeared, this atmosphere probably contained substantial hydrogen compounds (a reducing atmosphere).

   - A thicker reducing atmosphere would have had a higher vapour pressure, preventing atmosphere freeze-out at the poles and allowing water to remain liquid instead of vapourising immediately. It also would have created a greenhouse effect, allowing water to remain liquid instead of freezing. Ironically, since then, the presence of water may have greatly thinned out the atmosphere by aiding the lock-up of much atmosphere gas in carbonate rocks. The deep layer of Martian dust probably holds still more gas absorbed to the huge surface area of trillions of dust particles.

Other Examples

Among many other examples of similarities of planetary atmospheres are the following:

- Both Mars and Venus provide models of how planets transport their atmosphere constituents vertically. Vertical transport on Earth is an important part of understanding how trace gases such as fluorocarbons might affect our ozone layer and weather. Interest in this began as a result of findings about the effect of chlorine compounds on stratospheric ozone. These

findings were derived from Venus studies, and have led to government regulation of a billion dollar industry.

- Atmospheric wave motions may be the key to understanding all weather and climate. The Earth's temperate zones' cyclones and anti-cyclones are horizontal waves. Venus' sluggish surface winds are believed to transfer their huge momentum to the thin upper atmosphere, producing 200 mph (322 km/h) winds, by cascading wave motions. Large temperature and velocity waves on Mars appear to be an everyday feature. Venus, Mars and Jupiter exhibit a variety of other wave motions. (Jupiter's Great Red Spot may be a standing wave). Waves appear to determine the weather patterns on Mars, Venus, Jupiter and Earth. This variety of waves makes the general study of wave motions easier.

- The drivers for Venus' atmosphere circulation appear to be an equator-to-pole Hadley cell (a single continuous circulation pattern for each hemisphere). The Earth's equatorial circulation (the easterly winds of the Northeast Trades result from a Hadley cell, and the Martian summer hemisphere easterlies appear to be of this type.

- Basic differences between the terrestrial planets are shown by temperature differences between their equators where the most solar heat is absorbed, and the poles where almost no heat is absorbed. For Venus, the difference is 2%; for Earth, 15%; and for Mars 40%. If a planet distributes its heat evenly (like Venus), its atmosphere is, by definition, efficient in transporting heat to the cold poles, instead of radiating it back to space. This efficiency correlates almost exactly with the atmosphere's pressure and density. Venus' thick atmosphere circulates most of the heat planet-wide. Mars thin atmosphere loses almost half of it.

Acknowledgement
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SOYUZ MISSIONS TO SALYUT STATIONS

By Phillip S. Clark

Introduction

Commencing in 1971, the Soviet Union has launched six named orbital stations under the "Salyut" identity, the first of which was clearly timed for the tenth anniversary of Yuri Gagarin's historic manned space mission. Salyuts 1-5 (together with a probable Salyut launch failure in July 1972 and the in-orbit failure Cosmos 557) were the first generation of Salyut station, while Salyut 6 has been identified as the first of the second generation.

The Soyuz spacecraft, which seems to have been originally designed for the Soviet Union's still-born manned lunar programme, has been adapted for ferry missions to the Salyut stations: Soyuz 10 and 11 retained the solar panels used on the Soyuz 1-9 missions for power, but the ferries beginning with Soyuz 14 have dispensed with these (after the solo Soyuz 12 manned test flight). Up to the time of writing (November 1978), we have had 31 named Soyuz craft,* and commencing with Soyuz 14 only three have used solar panels and have not been related to the Salyut programme: Soyuz 16 was the ASTP test flight, Soyuz 19 was ASTP itself and Soyuz 22 was a solo flight which began the manned phase of the Intercosmos programme.

It is *not* the intention of this article to review all the flights which have taken place in the Soyuz-Salyut programme from the "mission results" point of view. In late 1976 the writer developed a graphical method which could be used to estimate the durations of manned flights to Salyut stations, and this idea will be fully developed in this article: the method has previously been described briefly in print [1], although it has been circulated among the writer's correspondents since it was initially developed.

Using the graphical method the writer will here look in detail at the Salyut 6 missions in 1977-1978, and will project forward to future landing opportunities. Finally, the earlier missions to Salyuts 1-5 will be briefly reviewed, with the intention of estimating the intended lifetimes of in-flight Soyuz failures.

* *Plus the April 1975 launch failure.*

Soyuz Landing Conditions

The writer has described elsewhere [2] the mathematical results of comparing the recovery times of Soyuz craft with the time of sunset at the landing site. Unfortunately, the landing sites were not available to a great degree of accuracy, but thanks to work by Mr. R.F. Gibbons it has been possible to refine the data previously published. Basically, the successful Soyuz missions come down less than 0.20 of a day before sunset at the landing site (decimals of a day are used here for convenience). This is brought out by Fig. 1, which shows the times of Soyuz landings in decimals of a day GMT with the date of recovery along the "x-axis". Superimposed on this figure are three pseudo "sine curves": the one marked "0.0" shows the time of sunset at the mean landing site of about 50.4°N, 69.3°E, "0.1" refers to 0.1 of a day before sunset and "0.2" that time before sunset. Of the known successful flights, only a few are outside the area enclosed by the curves. Therefore, for any date, it is possible to estimate the landing time limits for a successful flight if no other constraints are added.

However, in practice another constraint is added: the orbit of a Soyuz or Soyuz-Salyut complex precesses, and therefore passes will take place over the landing site earlier each day, the shift in time depending on the altitude of the spacecraft. Therefore, for part of its mission, a spacecraft will be unfavourably placed for a landing under the nominal conditions which Fig. 1 brings out.

In the case of Salyut 6, which repeats its ground track after 31 orbits, a pass over a given area will take place about 48 minutes earlier in each two-day period. Figs. 2(a) and 2(b) show the graphs for the Salyut 6 missions, and it will be noted that pairs of sloping lines have been added to the basic Fig. 1 picture. Of the two lines, the left-hand one represents the time of launch for each date, while the right-hand line

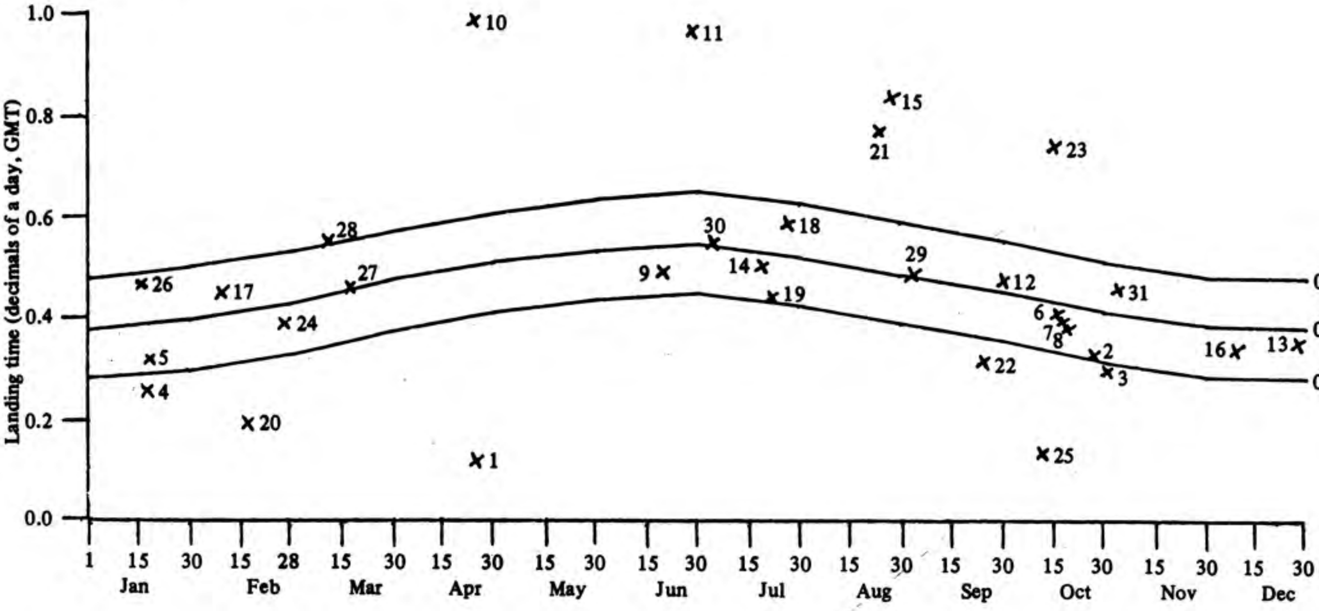


Fig. 1. Plot of Soyuz landing dates *vs* the time of landing. The three "curves" are linear approximations to the time of sunset, 0.1 of a day before sunset and 0.2 of a day before sunset at the landing site. However, for convenience, these times have been converted to GMT. The number next to each data point refers to the Soyuz mission depicted.

shows the *mean* landing line, which is off-set from the first by roughly one orbit (1½ hours). Therefore, it is clear that under nominal conditions a landing will come while the right-hand line is within the area bounded by the lines marked "0.0" and "0.2": in fact, for Salyut 6, the missions up to and including Soyuz 31 fall within the area bounded by the lines "0.0" and "0.1".

Review of Salyut 6 Missions

The missions to Salyut 6 can be broken down into two main periods: the first relates to the extension of the Skylab duration record to 96 days 10 hours by the crew launched on Soyuz 26, while the second period covers the mission of the crew launched on Soyuz 29 who have gained the manned duration record of 139 days 14 hours 48 minutes.

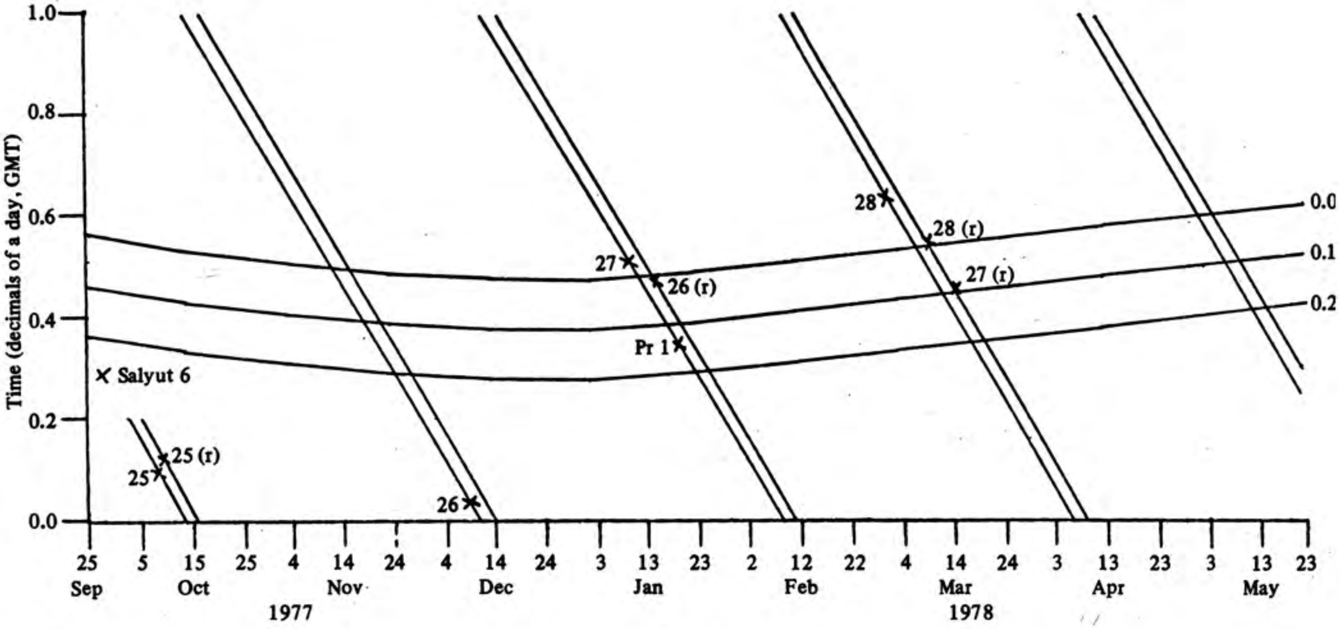
The first mission to Salyut 6 was the unsuccessful Soyuz 25, which returned to Earth after failing to achieve a "hard dock" with Salyut after a "soft dock". At the time, the mission was reported to have been the long-predicted three-month mission, although the writer reserves judgement on this. The first landing opportunity was the period November 16-29 (more probably to November 23) for a flight of 38-51 days (more probably to 45 days). If the next landing window had been intended for use, the mission would have lasted 98-104 days.

However, using the former duration, it was possible to predict that the Soyuz 26 mission would come the week of 8 December 1977. In fact, the launch came on 10 December and while the crew duration was over 96 days, Soyuz 26 was in orbit for 37½ days, a fair fit with the estimated Soyuz 25 figure. Table 1 provides the data for calculating the mean interval between launch windows to Salyut 6, with the first set of data measured from the launch of Soyuz 26. The third column of the Table shows the interval between the launches during the "Soyuz 26 crew dominated" period, while the fourth gives the number of launch windows between the launches. The third column divided by the fourth gives the average interval in launch windows in days, quoted in the final column.

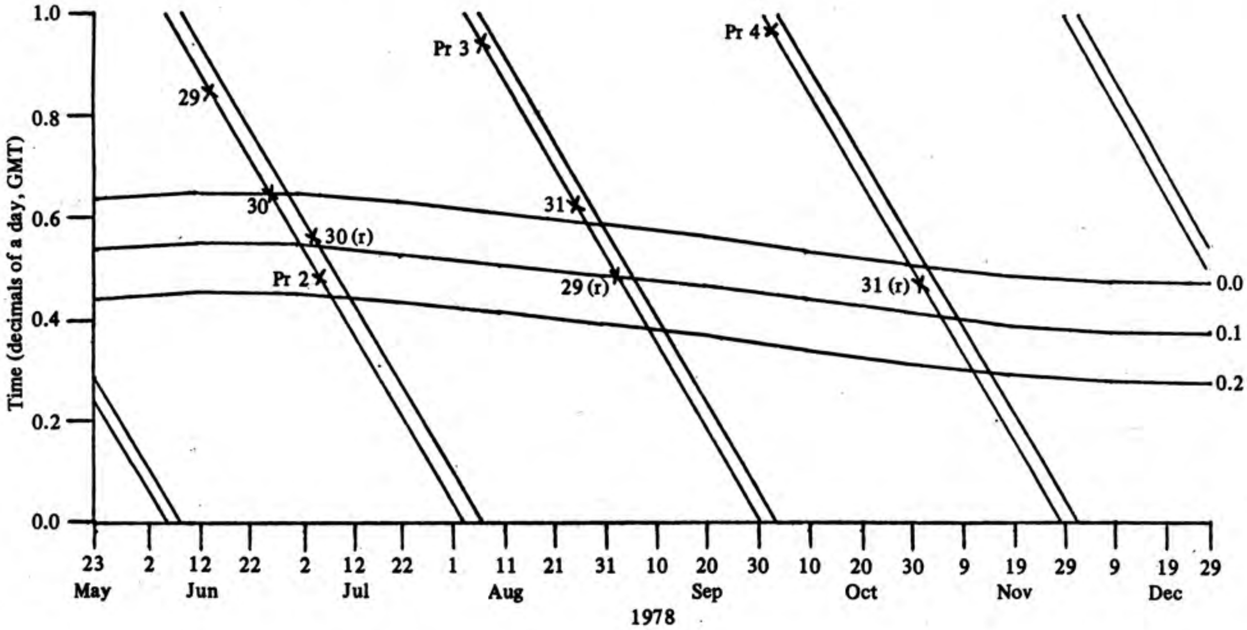
After the crew launched in Soyuz 27 returned to Earth in Soyuz 26 (thus freeing the rear docking port on Salyut) the unmanned Progress 1 cargo ferry was launched. It will be noted that the launch came within a Salyut 6 landing window, so if the launch of the ferry with its supplies had failed, the crew on Salyut could have returned to Earth under the nominal landing conditions. Soyuz 28 was the first flight to carry a non-Soviet and non-American into space, Vladimir Remek. Like the two subsequent manned Intercosmos missions, the crew were in orbit for eight days. However, the crew of Soyuz 28 came down just *after* local sunset (about 17 minutes after the event): television pictures of the landing showed that the sky was still light, and since the landing came in a snow-covered area the spacecraft was easily observed on the ground. By the time the crew had emerged from their descent module and were giving their first post-flight interviews darkness had set in. The landing of Soyuz 27 with the long-duration cosmonauts came close to the mid-point of the March 1978 landing window, thus allowing the recovery team plenty of time to examine the crew in daylight, rather than have to try and find them in darkness.

Salyut 6 remained unmanned for a period of some three months, at which time Soyuz 29 was launched, soon to be followed by the second Intercosmos crew in Soyuz 30. After the recovery of the Intercosmos team, the Progress 2 ferry was launched, again at a time so that if the flight had failed the crew left on Salyut could have returned to Earth under the optimum landing conditions. After Progress 2, however, the Soviets seem to have accepted the craft as reliable enough not to be restricted to launches geared to an early return of the Salyut crew if the launch failed. Neither Progress 3 nor Progress 4 were launched anywhere near to a landing window.

The end of August saw the launch of the third manned Intercosmos mission to Salyut 6, launched on Soyuz 31. Like Soyuz 26/27, we were treated to a spacecraft change, with the Intercosmos crew coming down in Soyuz 29, and the new Soyuz 31 remaining docked with Salyut. On 7 September the Salyut crew entered Soyuz 31 and undocked from the rear end of Salyut: the station then rotated through 180° and Soyuz re-docked, thus freeing the



Figs. 2(a) and 2(b). Plot of Salyut 6 related missions from the station's launch in September 1977 to November 1978. Salyut 6 itself is identified in full, but sole numbers refer to the Soyuz ferry flights. An "r" following the number shows that the recovery point is being depicted. The unmanned Progress ferry flights are depicted at launch by "Pr" followed by the mission number. The decay time of the Progress craft is not generally given, but the retro-fire time of Progress 4 was announced to be 16h 28m GMT on 26 October 1978. The landings of Progress missions are not, therefore, shown in the diagrams.



rear docking unit for the launch of Progress 4. This manoeuvre took place at a time such that if the re-docking had failed, the Soyuz could have come down within the normal landing window constraints.

An innovation appeared with the Soyuz 29 landing, which in retrospect seems to have been a rehearsal for the recovery of Soyuz 31. Soyuz 29 came down one orbit earlier than expected,on the *launch* time line rather than the *landing* time line (see Fig. 2(b)). Table 2 shows the landing windows for the various Salyut-related missions, and it will be noted that the nominal Soyuz 31 landing opportunity opened on 3 November, although the craft came down on the previous day. Since landing came one orbit earlier than usual for Salyut 4/6 "civilian" station missions, the craft landed in daylight rather than darkness. The result of using this "early orbit" landing opportunity is that the landing window will open about three days earlier than the usual nominal one.

Table 1 which follows is a summary of the main missions to Salyut 6, giving the mean interval in launch windows. For the Salyut 6 first occupation period, the interval was, on the average, 1.9664442 days, or two days less 48.32 minutes:

Table 1. Launches of Soyuz 26-31 and Progress 1-4.

Prime Spacecraft	Subsequent Launch	Interval days	n days	Launch Window days
Soyuz 26	Soyuz 27	31.463	16.0	1.9664515
	Progress 1	41.296	21.0	1.9664762
	Soyuz 28	82.589	42.0	1.9664048
		Mean (1)		1.9664442
Soyuz 29	Soyuz 30	11.799	6.0	1.9665000
	Progress 2	21.631	11.0	1.9664545
	Progress 3	53.093	27.0	1.9664074
	Soyuz 31	71.774	36.5	1.9664110
	Progress 4	110.120	56.0	1.9664286
		Mean (2)		1.9664403
		Overall Mean		1.9664418

for the second occupation begun by the Soyuz 29 (launched) crew, the window is two days less 48.33 minutes. The overall average comes to two days less 48.32 minutes.

Future Use of Salyut 6

The present writer has *no* intention of attempting to speculate over the intended durations of future missions to Salyut 6, other than generally expecting the Intercosmos missions to continue to be about eight days in duration: it is possible that the flights will be increased to about two weeks at some stage. However, the Soviets have said that the second generation Salyuts can be operated for 3-5 years, so it might be interesting to project the Salyut 6 landing windows forward for the years 1979 and 1980.

When one compares the two parts of Fig. 2 (covering the years 1977 and 1978), it will be noted that the sloping launch and landing lines are shifted by − 14 days on the average, so estimated landing windows will be similarly shifted (plus a correction required to allow for the change in the time of sunset in the two week period). Using this approach, and assuming that the normal landing opportunities are used, the writer estimates that the 1979 and 1980 landing windows will be as follows:

1979	1980
Jan 2-Jan 12	Jan 1-Jan 2*
Feb 25-Mar 7	Feb 13-Feb 22
Apr 22-May 1	Apr 8-Apr 18
Jun 17-Jun 28	Jun 3-Jun 14
Aug 18-Aug 30	Aug 4-Aug 16
Oct 20-Nov 1	Oct 6-Oct 19
Dec 21-Dec 31	Dec 7-Dec 18

The first two dates in 1980, marked *, are a continuation of the final launch window of 1979. It will be interesting to see how the Soviets actually use the projected launch windows. I would point out, however, that the calculations assume that the *normal* landing line is used, rather than the *launch* line as has been the case with Soyuz 29 and 31 (as previously noted).

Table 2. Soyuz Flights to Salyut Stations.

Salyut	Soyuz	Launch	Recovery	Landing Window
		1971	1971	1971
1	10	Apr 22	Apr 24	May 16-May 26
	11	Jun 6	Jun 29	Jul 9-Jul 21
		1974	1974	1974
3	14	Jul 3	Jul 19	Jul 15-Jul 27
	15	Aug 26	Aug 28	Sep 15-Sep 25
		1975	1975	1975
4	17	Jan 10	Feb 9	Feb 6-Feb 18
	18A	Apr 5	Apr 5	May 26-Jun 7
	18	May 24	Jul 26	Jul 24-Aug 6
		1976	1976	1976
5	21	Jul 6	Aug 24	Aug 29-Sep 10
	23	Oct 14	Oct 16	Oct 28-Nov 9 (Dec 27-Jan 8 1977)
		1977	1977	1977
	24	Feb 7	Feb 25	Feb 18-Feb 28
6	25	Oct 9	Oct 11	Nov 16-Nov 29 (1978 Jan 15-Jan 26)
		1977	1978	1978
	26	Dec 10	Jan 16	Jan 15-Jan 26
		1978	1978	1978
	27	Jan 10	Mar 16	Mar 10-Mar 21
	28	Mar 2	Mar 10	Mar 10-Mar 21
	29	Jun 15	Sep 3	Aug 31-Sep 13
	30	Jun 27	Jul 5	Jun 30-Jul 12
	31	Aug 26	Nov 2	Nov 3-Nov 15

Review of Previous Salyut Missions

Of course, the same methods described above for Salyut 6 can be applied to the earlier Salyut missions: the associated ferry flights to Salyuts 1 and 3-6 are given in summary form in Table 2, which also indicates the appropriate landing windows which were used (or intended to be used).

(a) Salyut 1

Two manned flights were made to Salyut 1, neither of which seems to have flown its full duration. Soyuz 10 docked with Salyut, but the crew were unable to transfer to the station, and the mission was therefore aborted. Table 2 indicates that the landing window was the period May 16 to May 26, implying an intended duration of 23-33 days. Soyuz 11 was more successful, since the three-man crew were able to enter Salyut and work on board for some three weeks. However, there were reports of problems with the station (for example, an electrical fire at one point) and the mission seems to have been terminated earlier than planned. The nominal landing opportunity would have given a duration of 33-45 days, most probably the early part of the window being used in view of the estimated Soyuz 10 flight time.

(b) Salyut 2 and Cosmos 557

In April and May 1973 two Salyut stations were launched, both of which failed in orbit and no manned flights appeared. Salyut 2 seems to have had the characteristics of the primarily military Salyuts 3 and 5 stations which flew at an average altitude of about 265 km: Cosmos 557 (which must have failed during the launch phase or very early in its orbital flight for it is not to be given a Salyut number) seems to be akin to the primarily civilian Salyuts 4 and 6 missions, and probably should have manoeuvred into a 360/340 km orbit. No attempt will be made to estimate the duration of manned flights to these stations if they had proved successful, but from the intended orbits and known launch times,

launch thrust of the Shuttle.

Other studies concentrated on concepts for fabrication and assembly of space structures including geosynchronous platforms as well as concepts for providing future satellite services such as placement, retrieval, and on-orbit maintenance and repair.

Space and Terrestrial Applications

After more than five and one-half years during which it orbited the Earth 28,854 times at 870 km (540 miles) and sent back 271,786 multi-spectral images, Landsat 1, NASA's first Earth resources monitoring satellite, was turned off on 23 March 1978. On 5 March, a more advanced Landsat 3 had been launched into a near polar orbit from the Western Test Range (WTR). In addition to the multi-spectral scanner carried by Landsats 1 and 2, Landsat 3 also carried a two-camera panchromatic return-beam vidicon system, which to date has transmitted 12,000 scenes with a resolution better than 40 metres (130 ft).

In December, a contract was awarded to the General Electric Space Division in Philadelphia for a still more advanced Earth resources monitoring satellite, Landsat D, to be launched in the last quarter of 1981.

An example of NASA's Landsat Application Systems Verification and Transfer (ASVT) programme is an agreement with the Appalachian Regional Commission to test and evaluate the use of Landsat data for the identification of high-potential gas shale exploration areas. The area to be explored extends from the Mississippi Basin to the Appalachian Mountains. Another ASVT programme was started with the Pacific Northwest Regional Commission to use Landsat data for natural resource management in Washington, Idaho and Oregon.

The ASVT programme is a continuing effort by NASA to make space technology accessible to state and local governments, private industry and universities.

A major Landsat experiment completed in 1978 was the LACIE (Large Area Crop Inventory Experiment) programme. The experiment, begun in 1974, proved that Landsat data, coupled with surface observations and information from U.S. operational environmental satellites could forecast wheat production on a global basis.

In monitoring the Soviet wheat crop harvested in 1977, the LACIE estimate of 91.4 million metric tons was less than one per cent below the official 92.0 million tons reported by the Soviets.

Environment

The Environmental Observation Division of NASA had four major satellite launches during the year:

- *Applications Explorer Mission* (AEM), or Heat Capacity Mapping Mission (HCCM), launched from Vandenberg on 25 April, a satellite designed to measure day and night temperature differences on the Earth's surface.

- *Seasat*, launched from Vandenberg on 24 June, designed to study the Earth's oceans. Seasat returned data for 106 days before a massive short circuit ended data transmission on 10 October. Although a short-lived mission, Seasat sent back valuable data on ocean surface winds, currents, wave heights and ocean topography, and in doing so proved the feasibility of this type of mission.

- *TIROS-N*, a NASA-designed, third generation weather satellite, which was turned over to the National Oceanographic and Atmospheric Administration as an operational satellite on 30 November.

- *Nimbus-G*, the first pollution monitoring satellite. New instruments on this spacecraft are designed to detect Earth and solar radiation parameters, total ozone amounts, sea ice concentration, sea surface temperatures, wind speed, atmospheric water vapour, rain rates and stratospheric temperature profiles.

1978 was also the year of tracking moving targets on Earth from the Nimbus-6 satellite – the first balloonists to cross the Atlantic Ocean (Eagle II), a Japanese explorer and his dog sled over the North Pole, and an experiment in Egypt aimed at learning more about the laws of sand movement for possible application in saving fertile areas from the ever-encroaching deserts.

A technique for measuring the height of cloud tops using simultaneous daytime observations from two GOES satellites has been developed. This will provide estimates of cloud top height to an accuracy of better than 500 metres (1,640 ft), which far exceeds what is currently available.

The application of this technique can lead to improved weather prediction models and can be used to estimate the heights of thunderstorms.

Several studies were completed this year which will provide improved knowledge of how to construct various types of climate models. Data from a Nimbus infrared sensor has been used to improve understanding of the gross structure of the boundary layer of the atmosphere over oceans. This will help in developing and validating seasonal climate prediction models.

Technology Utilization

NASA's Technology Utilization Program continued as the agency's focal point for the transfer of aerospace technology into other sectors of the national economy.

The following statistical highlights for 1978 give an insight into the scope of this increasingly important effort:

- A broad-based programme of 70 applications engineering projects was continued in the on-going effort to apply aerospace technology and know-how to solve public sector problems ranging from development of advanced medical instruments to fire-fighting devices. Seven industrial applications centres, two state technology applications centres and the Computer Software Management and Information Center (COSMIC) continue to expand their services to industry and state and local governments, having served over 13,000 users in 1978. Income from services was $2.2 million dollars, an increase of 28 per cent over the previous year.

- The *Tech Brief Journal* reported 725 new NASA innovations, products and processes and was distributed quarterly to 50,000 requestors.

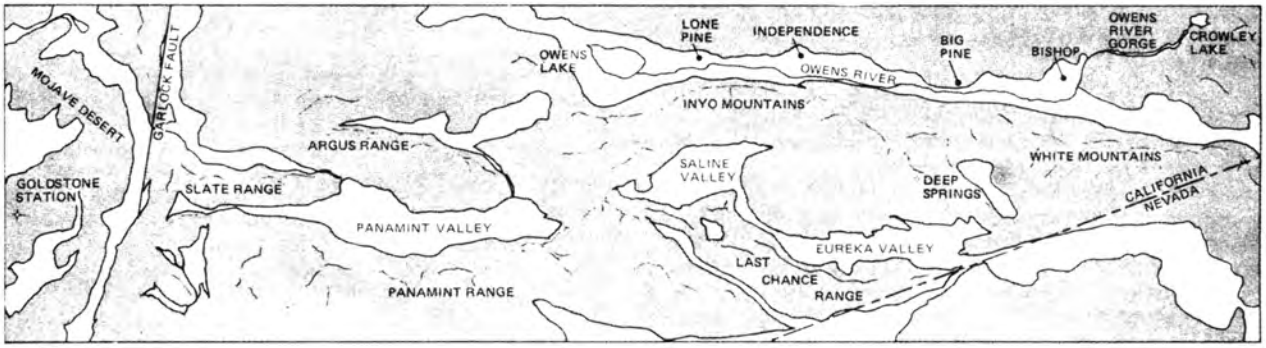
In August, the four-member family of Dr. Charles W. Swain, a professor at Florida State University in Tallahassee, ended its year-long experiment of living in the NASA Langley Research Center's "Tech House," a conventional house equipped with unconventional space-age technical systems designed to save money and energy.

Preliminary results show that:

- Energy was less than half of that used in a conventional, all-electric home.

- Total dollar savings from reductions in energy and water use amounted to more than $1,200.

At the Marshall Space Flight Center, Frank J. Nola, a space flight engineer invented an inexpensive, yet revolu-



Radar view of Eastern California was taken by Seasat on 7 July 1978. Covering a region 200 by 62 miles (322 by 100 km) it was received in less than a minute during a nine-minute sequence starting below Mexico's Baja Peninsula and ending on the British Columbia coastline. Surfaces which reflect radar waves poorly are dark and the best reflecting surfaces are bright (note the spot of the Goldstone antenna which was receiving signals from Seasat, *extreme left*).

tionary device he calls a Power Factor Controller, or "Motor Mizer." The small device can continuously determine the precise amount of electricity a household or industrial motor needs to perform efficiently. It does this by sensing changes in voltage and current as the workload increases or decreases.

Tests conducted on over 30 motors indicate the savings will range up to 60 per cent, depending on the workload. Since a reported 64 per cent of all electricity generated in the United States goes to operate electric motors, the "Motor Mizer's" potential for achieving energy savings is obviously enormous.

At the Lewis Research Center, Cleveland, Ohio, a new device to reduce and regulate pressure inside the eye during glaucoma surgery was developed by Cleveland opthalmologist Dr. William J. McGannon and Dr. Dong H. Shin of the Kresge Eye Institute, Wayne State University, Detroit, Michigan. The device is based on fluid systems and components Technology developed by NASA. Dr. McGannon also worked on the development of a new surgical instrument for the removal of hard eye cataracts. NASA and the National Eye Institute, Bethesda, Maryland, have signed a cooperative agreement to conduct laboratory and clinical tests on the device.

Space Research and Technology

Space research and development provides advanced technology for future space missions. These technology-development programmes address requirements for advanced information systems; spacecraft, power and transportation systems; and Shuttle technology payloads.

Emphasis of the information systems programme is to develop technology to increase the efficiency and reduce the cost of data acquisition, reduction and dissemination. Significant progress was achieved in technology development for a solid-state imaging camera, annular suspension pointing system, synthetic aperture radar data processor and the spherical array antenna.

The spacecraft systems programme work included new concepts in deployable structures, continued efforts in erectable structures, automated assembly operations and navigation techniques, chemical and electrical propulsion and advanced entry technology.

Power systems technology development continued in support of future Shuttle-based needs in near-Earth space operations and for systems to support electric propulsion.

In space transportation systems Earth-to-orbit and return research, emphasis was focused on technologies to reduce operational costs. Increased versatility, including high-thrust reusable systems and high-performance low-thrust systems, was the focus in orbital-transfer vehicle technology development.

The Shuttle technology payload programme is designed to extend research and technology into space. More than 20 experiments were selected this year. The programme consists of four major elements: Orbiter Experiments; Long Duration Exposure Facility experiments, Spacelab payloads and free-flying payloads.

The development of the Long Duration Exposure Facility neared completion and development of the 48 candidate experiments is well underway.

International

In 1978, NASA's international activity highlights included: successful launching of three spacecraft in projects involving major foreign contributions – TIROS-N, International Ultraviolet Explorer (IUE) and International Sun

Earth Explorer (ISEE-3); conclusion of agreements with the European Space Agency (ESA), Canada and India for the direct reception of data from NASA applications satellites; steady progress in Spacelab and Remote Manipulator System development programmes abroad; selection of Payload Specialists for the first Spacelab mission; seven international reimbursable launches; completion of the Joint American Soviet Particle Intercalibration (JASPIC) Project; establishment of a space science and application study programme with Japan; and discussions with the People's Republic of China regarding the possible sale by U.S. industry and launch by NASA of the domestic communications satellite.

The sensors of TIROS-N, launched on 13 October for the National Oceanic and Atmospheric Administration (NOAA) are multi-national in character. Each operational spacecraft in the series will carry a stratospheric sounding unit developed and funded by Great Britain and a data collect and platform location system developed, funded and operated by the French Space Agency, CNES.

NASA launched IUE, a cooperative project with ESA and the British Science Research Council (SRC), on 26 January. IUE is studying celestial objects that emit ultraviolet radiations not detectable from the ground. ESA contributed the solar array and the Madrid ground facilities. SRC, in collaboration with the University College, London, provided the four television camera detectors for transforming the spectral displays into video signals for transmission to the ground.

The objective of ISEE-3, launched on 12 August, in a cooperative NASA/ESA project, is to gain a better understanding of how the Sun controls the Earth's near space environment. The three-spacecraft project involves 117 scientific investigators representing 35 universities in 10 nations. NASA is responsible for ISEE 1 and 3, the Delta launch vehicles, tracking and data acquisition and data processing. ESA is responsible for the ISEE 2 spacecraft and its operation.

ESA continues to make substantial progress in the development of the Spacelab that will be carried to and from orbit in the Space Shuttle orbiter. Integration and testing of the engineering model is well underway and it is scheduled to be delivered to NASA in August 1979.

The Critical Design Review of the Remote Manipulator System for the Shuttle Orbiter being contributed by Canada was successfully completed in April 1978. Delivery of the first unit is scheduled for September 1979.

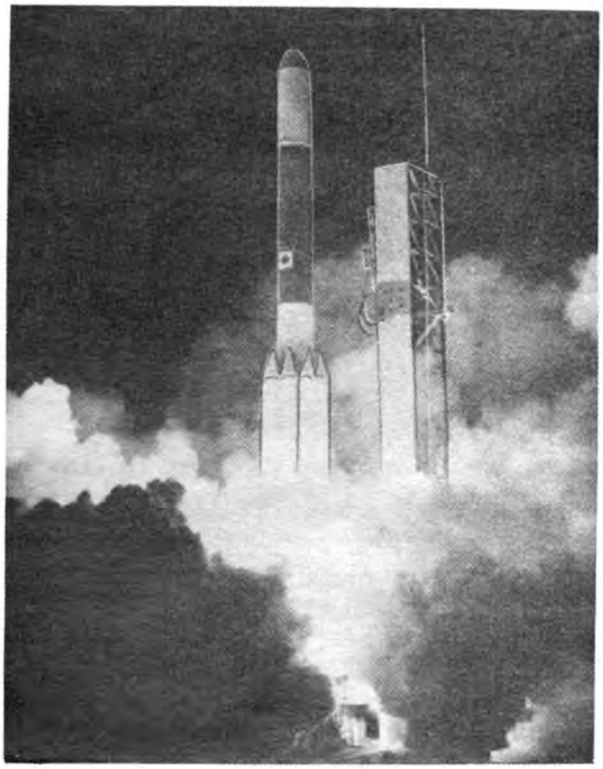
During 1978, several new agreements were included for the direct reception of data from NASA application satellites at stations funded and built by foreign agencies.

NASA and ESA signed three memoranda of understanding in Paris on 7 October concerning the acquisition by European ground stations, pre-processing and distribution of data from the Landsat series of satellites and several ESA-coordinated investigations involving data received in Europe from NASA's Nimbus 7 and Seasat satellites.

NASA and Canada's Department of Energy Mines and Resources (EMR) signed an agreement on 19 September to carry out a scientific investigations programme using Seasat data received directly at a ground station established by Canada at Shoe Cove, Newfoundland. However, in October, the Seasat ceased to function due to an electrical problem.

The Indian National Remote Sensing Agency signed an agreement with the U.S. in January 1978 under which it will build a Landsat ground station which will receive, process, and disseminate Earth resources data of South Asia. Similar stations are in operation in Canada, Brazil, Italy and Sweden. A station in Iran is expected to begin regular operations shortly. Stations are under development in Japan, India, Argentina and Australia and stations have been proposed for Upper Volta, New Zealand, Kenya, Thailand, Romania, Chile and Zaire.

In 1978, NASA successfully launched seven international satellites for which the U.S. was reimbursed.



ANIK-B, a Canadian domestic communications satellite, was launched aboard Delta 147 from Complex 17 at Cape Canaveral Air Force Station on 15 December 1978.

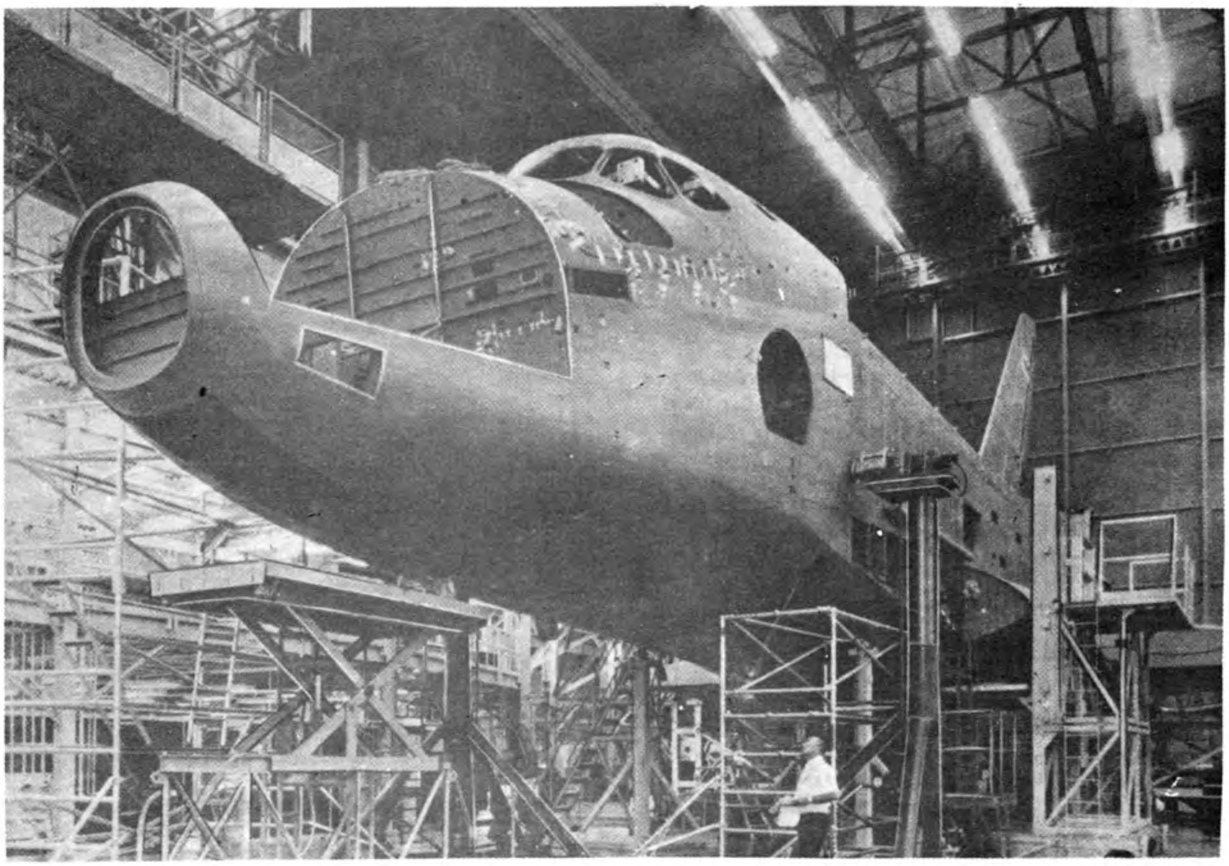
- The International Telecommunications Satellite Consortium (INTELSAT) IV-A programme represents an investment by 101 nations of nearly $296 million (U.S.) in a worldwide communications satellite network. NASA successfully launched Intelsat IV-A F-3 on 6 January, and Intelsat IV-A F-6 on 31 March. The satellites both operated in geostationary orbit over the Indian Ocean to provide communication services to over 40 countries in that region.

- On 7 April, NASA launched the medium-scale Broadcasting Satellite for Experimental Purposes (BSE), for Japan's National Space Development Agency (NASDA). BSE is testing new methods of transmitting high quality colour television economically to the Japanese islands and Okinawa through the use of small, low-cost ground receivers.

- Orbital Test Satellite-2 (OTS-B) was launched on 11 May for ESA. This is one of two experimental models under study by ESA for use as the foundation of a fully operational European regional communications satellite system.

- On 14 July, NASA launched the second Geostationary Scientific Satellite (GEOS 2) for ESA. The primary mission of GEOS 2 is to study the Earth's magnetosphere. GEOS 2 will continue seven experiments begun by GEOS 1.

- NATO III-C, the third and final communications satellite in a new series to serve the North American



SPACE SHUTTLE ORBITER 102 'COLUMBIA' during assembly at Rockwell Corporation Space Division. By the end of 1978 work was well advanced at the Palmdale facility. 'Columbia' is due to be launched from the Kennedy Space Center later this year.

Treaty Organization (NATO), was launched on 15 November.

- Canada's most advanced domestic communications satellite (ANIK-B), launched on 15 December, is the fourth domestic communications satellite launched by NASA for Telesat Canada which owns and operates the satellites as the country's Domestic Communications Satellite System. This is a second generation satellite in a series often called Telesat and ANIK-B is referred to as Telesat-D by NASA.

NASA selected two American Payload Specialists and ESA selected three European Payload Specialists for the first Spacelab mission. Dr. Michael L. Lampton and Byron K. Lichtenberg were selected as the U.S. Payload Specialists. ESA selected Dr. Ulf Merbold (German), Dr. Claude Nicollier (Swiss) and Dr. Wubbo Ockels (Dutch).

One American and one European eventually will be selected to fly aboard the Earth-orbiting space laboratory and operate the science instruments.

A meeting of the U.S./U.S.S.R. Working Group on Near-Earth Space, the Moon and the Planets was held at Innsbruck, Austria, on 7-9 June to discuss Venus 1978 missions, possible Venus 1983-4 missions, and important future lunar and planetary science objectives. The U.S. and U.S.S.R. agreed to exchange data obtained from the exploration of Venus in connection with the 1978 missions to enhance the scientific value of the respective missions.

Objective of the JASPIC project concluded in September to compare the techniques used by the United States and Russia over the years to deduce the intensity of energetic electrons and protons coming down into the lower ionosphere. The project is designed to gather experimental evidence concerning the role of these particles in creating ionization in the lower ionosphere at night at mid latitudes. Eight rocketborne experiments were conducted jointly during June from NASA's Wallops Island location and the Soviet research ship, Professor Vize, located off Virginia's Eastern shore. The final rocket, a Nike-Apache, was launched on 27 September.

NASA and Japan's Space Activities Commission have established a joint study programme to assess possible co-operative space science and applications projects of mutual interest. The first meeting of the study group was held in Tokyo on 12-15 December.

NASA hosted a visit of a space delegation from the People's Republic of China (PRC), headed by Dr. Jen Hsin-min, Director of the China Space Technology Research Institute, from 28 November to 20 December. The purpose of the visit was to discuss the possible sale by U.S. industry and launch by NASA of a domestic communications satellite and possible cooperation in the Landsat programme. After discussions in Washington, NASA representatives accompanied the Chinese delegation on a series of visits to NASA Centers and U.S. aerospace industries.

Acknowledgements

The editor wishes to thank Bill Pomeroy and Mary Fitzpatrick of NASA Headquarters, Washington, D.C., for information used in this summary.

LIVING IN SPACE STATIONS

A second interview with Joseph P. Kerwin, M.D., Chief, Mission Specialist Group, Johnson Space Center, Houston, Texas.

Last year Soviet cosmonauts broadened their experience of manned space flight in missions lasting 96 and 139 days respectively. What are the physiological and psychological aspects of such extended missions? And what are NASA's future plans? Mario Mutschlechner returned to the Johnson Space Center to find out. His interview was recorded before NASA announced that Skylab would be abandoned to its fate.

MM: *During our initial talk in April 77 [1] you stressed that there is still much to be learned about the long-term adaptation of man to zero-g. So we need a long-durational space station research programme, either via the reactivated Skylab or the Shuttle-Salyut programme or other zero-g stations. What are NASA's plans?*

JK: NASA's plans for a long term space station medical research programme are really ideas. They are not projects, because they have not been presented to the Congress and approved and funded. We are still climbing this enormous foothill, which is the Shuttle Test Program, and we won't know until we get to the top of that what mountain ranges lie beyond! There is really no desire on the part of NASA to bring forth a definite programme to use the Space Shuttle in these advanced ways until we are sure what its performance is going to be and when it will be ready to fly; you know that is a bit 'iffy' right now!

MM: ***Yes, I heard about problems you have with the main engines of the Shuttle and I also heard about problems with the reactivation of the Skylab.*** Maybe there is not enough time left to do something about that and a maybe naive idea occurred to me: the Russians are up there all the time. Couldn't they do something?*

JK: I really don't think they could. I think it would take longer to design a programme with the Russians than it would to go and get it ourselves. Their orbits are different, because they launch from a totally different latitude. According to my understanding of the Russian spacecraft, although they are excellent for their purpose, they don't have a great deal of fuel and thrust for changing the orbital plane once they are up. So the rendezvous would be a very difficult thing for us to persuade them to do, and once rendezvoused, they would have to carry another propulsion system, and it would have to be capable of docking with the Skylab, with the old-fashioned Apollo docking port, which is not the kind we used on the joint Apollo-Soyuz mission. So problem, problem, problem! I don't think that would work. I think our best bet is still to go get it with the Shuttle. We might get there and we might not. But that problem doesn't really constrain the Shuttle. It is constrained by the Shuttle.

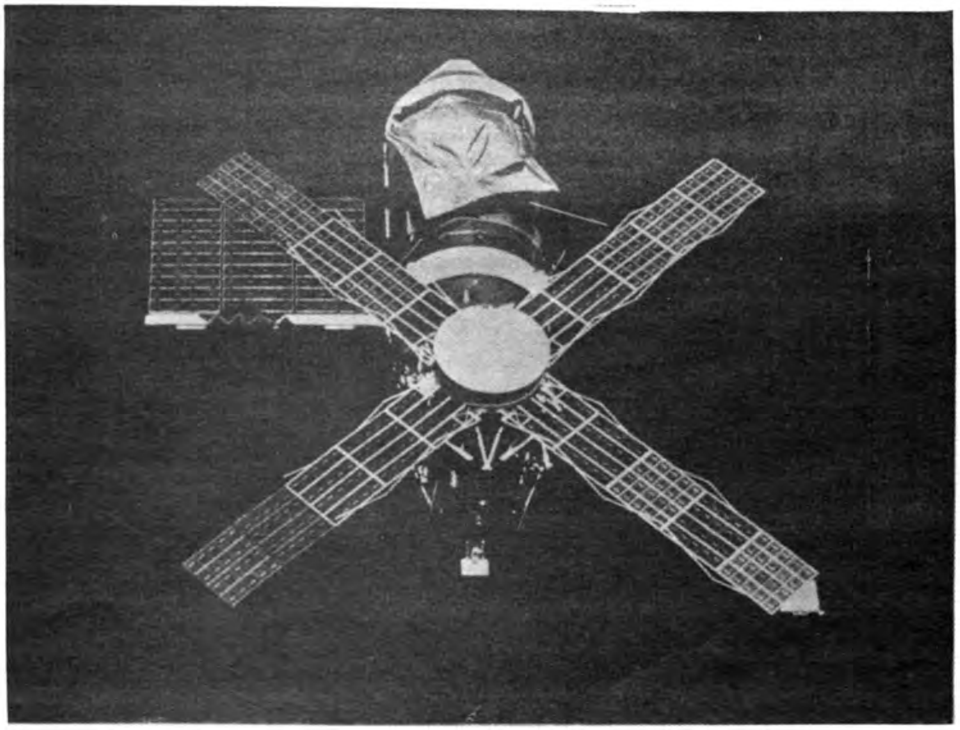
MM: *Yes, naturally. But it would be an advantage to have the Skylab. It is such a large station and....*

JK: Well, again. The problem of saving Skylab is independent of the question how useful it would be if we saved it.

MM: *There are other reasons why you want to save it?*

JK: We would prefer that, if it re-entered, it did so in a planned way to a known area. Splash it down in the Northern Pacific somewhere; that would be safe for everybody. As to whether we could refurbish and use Skylab again after we've boosted it, that's a question that is being studied. I am

* *NASA announced that planes to re-boost or de-boost Skylab had been abandoned on 18 December 1978. It will be allowed to re-enter the atmosphere under natural decay.*



SKYLAB RE-ENTRY. Although the 77-ton Skylab space station is most likely to re-enter over the ocean, emergency measures are being taken by the United States authorities in case any part should fall on land. In theory the station could fall anywhere between approximately 50 degrees latitude north and south of the equator. A Skylab command post is being established at NASA Headquarters in Washington to help co-ordinate activities with other agencies during the final orbits. Should debris fall on foreign soil, U.S. Department of Defense forces will provide any assistance that may be requested. (The 39 ton second stage of the Saturn 5 which placed Skylab into orbit re-entered harmlessly over the North Atlantic near the Azores in January 1975. Some debris from it landed in the sea (Ed.). Latest NASA prediction for Skylab orbital decay is June-July, depending on amount of solar activity.

NASA

a little bit sceptical whether it would be worth the cost to provide all the systems and all the equipment and all the oxygen and nitrogen and batteries and things that it would take to reactivate Skylab. It's like spending a great deal of money to refurbish a 1940 automobile. You love to do it maybe, if you're an automobile buff, but if you're interested in economy you can go and buy a Toyota and do better, OK?

MM: *Now another question in relation to the long-term adaptation of man to weightlessness. You have done all these studies in Skylab in relation to the cardiovascular system and its deconditioning in zero-g and to neuromuscular co-ordination and bone resorption. Now which is the main problem area from a long-term point of view? Obviously it's bone resorption....*

JK: Bone resorption is the only problem we have identified which seems to be possibly a severe problem.

MM: *Because it does not plateau?*

JK: It has not yet plateaued as of three months. It could plateau in six months and it would not be a problem. But you just have to fly and find out! There are doctors who have done some bedrest studies and they claim that it's not going to plateau, but I think that we just don't know. I think there is a good chance that it will!

MM: *So you think it's just a matter of flying for longer time to find out? There seems to be another approach with a diet: to balance the calcium loss with a calcium diet, to put it very simply?*

JK: It depends on why we are loosing calcium. If we are loosing calcium because the kidneys or the feces excrete a little more of it in weightlessness, then perhaps you could double the intake of calcium and over-power that effect, the excretion would increase but you'd get enough in your system to be balanced. There are several hypotheses and one is that it's a vitamin D and a kidney problem.

One of the forms of vitamin D which is manufactured by the kidney and which is the active form of vitamin D that causes absorption of calcium from the intestine is not being so transformed in the kidney. Now, if that was the case it wouldn't matter how much you ate, because absorption is impaired and you'll always be in negative balance. If that is true, and there are some experiments being proposed to measure these metabolites of vitamin D very accurately, then I don't know what you would do. You obviously try to find out why the kidney is not doing its work, not transforming the one metabolite to the next. You might be able to purify the metabolite needed and administer it to the crew. There are a lot of possible solutions, including diet, including drugs, including garments....

MM: *And exercise?*

JK: Well, exercise doesn't seem to have had any effect in Skylab; I was thinking of garments that exert a pressure on the long bones, because calcium is lost from the bones, and it seems to be lost exclusively from the lower half of the body.

MM: *Exclusively?*

JK: Well, we've made only a few measurements, but we've measured the density in the wrist and in the foot in Skylab, and there was loss of density in the foot but not in the wrist.

MM: *I think there was also loss in the spine, wasn't there?*

JK: We've been unable to measure accurately enough the bones of the spine, because they are so surrounded by muscle that it is difficult to get a very accurate X-ray of them, and the loss is so slow that it requires very accurate X-ray techniques to measure them. So that's a possible operational problem in medicine. I think another potential problem is just what the social structure of a space station should be that's up for very long periods of time; the optimum number of people, the mix as to age and sex, and the amount of room that is necessary, and so on. What kind of a little society should you create?

MM: *This is a point you touched already last time.*

JK: I probably did because we haven't learned anything new.

MM: *How should you!*

JK: How should we? There is no research activity on our part now. It's premature. I think you really find the answer to these problems by going and doing them in a progressive fashion over years.

MM: *This is a major problem concerning my question! I realise you can't have more data on these things as long as you don't do them, and this applies to one of the major questions I wanted to ask you: how does NASA try to overcome the psychosocial difficulties of long term confinement in small and isolated space stations? You are not experimenting now, but I suppose you have done many experiments?*

JK: In the 'Sixties there were a number of experiments done, but nothing in the 'Seventies to amount to anything, and I think that is wise because an experiment on the ground will never be quite the same; we don't know the mission durations we are talking about, and we don't know the crew sizes that will be needed for valid purposes.

We're not going to ask Congress to build us a one hundred men space station just to go up and put a hundred people up for a year. The thing will have to have some uses, and I think we are three or four years away from defining very well the uses of space stations. There are a number of possible uses as you know, and therefore the sizes needed in an approach to building a small one and slowly making it bigger, depend on the frequency with which the crew will be brought up and brought back, and how long they'll be left and so on and so forth. Until we get to the point where we have a programme, I don't think it's useful to simulate a situation we can't define.

The other approach to avoid psychosocial problems is to try and identify what the problem areas are and then eliminate them. If the problem is confinement you try and give them volume so they don't feel confined.

MM: *But that is a matter of cost.*

JK: It is cost, sure! It is always difficult to persuade engineers to give you additional weight and additional volume because you want people to be happy. They don't understand "happy". What do you mean, "happy"? It costs too much money to be happy and so it's a constant struggle! There are no solid numbers you could use to prove one thing or another. We know how much room is used per person on submarines and we know how the submarine world has attacked these problems, and they submerge for periods of three months and that's useful data; it's a good starting point. There is no use doing it all over again in a simulator. But, anyway, if we can provide sufficient room, good food, recreational activities, not only recreational activities but

honest, challenging work for the people to do, they are not up there just as guinea-pigs getting bored. In other words, by eliminating the conditions that may lead to the problems you'll reduce the problems a great deal!

MM: *That's true, but some people adapt better to a confinement situation than others; it might depend on their psychic make-up. I suppose you choose future astronauts in that sense also; you look for people who are able to do that. How do you proceed? What are the criteria?*

JK: I can only answer that in a general way. There is a lot of data in the psychology literature about this very problem, based on studies in submarines, studies in Antarctica and similar isolated outposts, studies in Sealab, etc. Psychologists, some of them, have strong opinions as to what the personality characteristics are that make someone adaptable or not adaptable, and some of these can be screened for. Some of them are more subtle and they regard the mix of personalities that you have. There is one that said: be careful, you need leadership, but you don't need very many of those people! If you have two or three up there they'll be competing with each other all the time and that's bad; that can lead to tension, and if you don't pay any attention to the leadership structure and who is in charge, then you can get into trouble, because people separate into cliques and they fight each other. From a practical point of view I don't know how to approach it, although I think we can sit down and figure it out when the time comes.

MM: *You've gone through this process yourself. I'm sure that in Skylab the three crews were chosen according to their psychological compatibility.*

JK: Well, I don't really think they were, except subconsciously. By giving the commander a voice in the selection of his crew you were automatically assuring a certain amount of compatibility on the assumption that the commander knows the people involved well, which they did in Skylab. Again, Skylab wasn't up long enough, confined enough or isolated enough to present big problems in this area. Again, the psychologists say three people is a stable number, because they break up two against one and you can sort of ostracise one member of the crew. But we were motivated, we were busy, we had an excellent command structure and consequently these problems didn't really get a chance to surface.

MM: *Did you get any training, any psychological training for Skylab?*

JK: Not as such, only by virtue of the physical training, of working together, and in Skylab we worked together for three or four years as crews because the mission kept being delayed.

MM: *But you didn't get any theory on it, like watch out for these factors?*

JK: There is a bias, I think, among pilots against psychology, against my insides being looked at and exposed too much, you know! If I have emotional failings I don't want them to be banded around and disected.

MM: *You think that's good because you have to have them?*

JK: My wife and I argue about this. She thinks it's not good. I don't think it's good either, but I don't think it's particularly harmful if the situation is structured, if an individual like that knows what to expect.

MM: *You've been in stress situations before so you know how you are going to react and how other people are going to react. That's part of the training programme, that's when people break up.*

JK: People like that are very good at reacting to acute stress. They don't panic. Their psychological mechanisms allow them to ignore those things. The question is how well they react to chronic stress of isolation in small groups where it's interpersonal relationships that become very, very important, and I don't think I know the answer.

MM: *Still in relation to this question: the Russians are up there for a long time, for more than three months. In Skylab you had a very large volume, but they have a much smaller volume. I think one of the main reasons to be able to stand confinement is motivation besides the work load.*

JK: Yes, but there will come a point when motivation is not enough, maybe. I saw an article in a newspaper, about the Russians, that said they were doing everything they could to prevent depression that was occurring on these long flights, and they gave some examples of this crewman and that crewman, who felt anxious and depressed and bored after long periods of time, and they were using books and music and phone calls to the family and things like that to try and avoid this problem and keep them busy.

MM: *This is obviously a very, very tough step into the future! I mean the small size. I think in fifty years this will have changed. Then the space stations will be large but now they're small.*

JK: Space stations will be large but maybe the trips to Mars will occur in small spacecraft. We will always have outposts!

MM: *Well, trips to Mars, that's a long way to go. But maybe you could tell me something in this context: what closed ecological life support systems are planned for zero-g stations on the Moon and who does the corresponding research?*

JK: Once again I have to say that most of the research in closed ecological systems was done in the 'Sixties by NASA and not in the 'Seventies. We have moved away from intensive studies of long-durational facilities. So we don't have much new data on that.

MM: *Nobody else has besides NASA? Nobody is working on that?*

JK: No, I don't think so. Not very intensively. The status right now, I think, is that as we move into space stations, the maximum durations as far as crews are concerned, will be three months, then six months, then maybe a year at the most, but starting with a few months at a time. It doesn't seem practical or inexpensive to build a space station with a totally closed ecological system for that kind of duration, particularly when you can reach and resupply it easily. So we will probably start with reclaiming water from the atmosphere and from waste, but nothing else.

MM: *That, I think, was already planned for Skylab, to reclaim water from waste, for example.*

JK: It was talked about and it was decided not to do it. It was too heavy and too expensive for the time involved. The next step after that would be to try to reclaim the waste material itself by virtue of feeding it to algae and then making sandwiches out of the algae. They didn't taste very good, but it can be done. Hydroponics, growing vegetables of

some kind....

MM: *These techniques are pretty advanced and will be used in one way or another?*

JK: And again, it's not my field, but I have read that in the opinion of some ecologists, to have a self-sufficient closed system you may require hundreds or thousands of individual organisms....

MM: *Different species. These are the two theories.*

JK: Yes, keep it simple and if you keep it simple, will it die? The answer, I guess, is we don't know and would have to try.

MM: *And neither NASA nor, to your knowledge, anybody else is really working on that?*

JK: The only people I know who may be looking into it are Dr. Gerald O'Neill, the Princeton physicist who is excited about habitats. He has done a lot of engineering studies and I suspect that he may have sponsored some studies (although not full-blown tests; he doesn't have that much money available) of how a closed ecological system might be worked out for a habitat, because he is talking about ten thousand human beings in a habitat with artificial gravity and totally dependent on their own resources, which means growing food, and again, I have read his plans only on a superficial level in that area; I don't know how deep into it he's gone. But I think that is a hundred years away so we have a lot of time to learn.

MM: *Now I have a question in relation to a different field. Do you think that the inclusion of women into the Space Program might help to clarify sex-related differences like psychological performance or do you believe that such differences will progressively disappear because of technology induced changes in medicine and society?*

JK: That's quite a topic! I don't think that there will be an immediate result of women in our programme elucidating the relationships between men and women in the world. We have six women out of two thousand million and that's a pretty small sample. Our flights will be short and I don't think that the fact that you fly a mixed crew together on a seven-day flight, even if you do it ten or fifteen times, is going to make obvious the true relation between the sexes.

MM: *No, naturally not, but it is one trend among others that occur in society since quite some time.*

JK: It's a social trend and all NASA is doing really is reflecting social trends; we're not breaking new ground we're going along with society, which is fine. That's the way we can operate. But I don't think that we're going to solve problems. We are obviously going to create some for ourselves, and that's nothing new either. When men and women are isolated together certain things tend to happen and these things can lead to cliqueing and jealousy and that sort of thing and I don't think we know any more how to solve that than anyone else does. I suspect NASA's official attitude will be: as long as you do your jobs, we're not going to tell you how to behave.

MM: *Yes, but I'm referring to the fact that men and women have more and more the same kind of jobs, the same kind of responsibilities, and so they become psychologically more alike, and that's a general trend, and, as you say, it's reflected in the Space Programme, it happens everywhere. Where do you think this leads?*

JK: We're in an area of philosophy here and of personal opinion. I don't think it leads ever to an identicality of men and women, because men and women are physically different; they are hormonally different, they are functionally different, at certain levels, and I think that some of these psychological or societal differences between men and women are anchored to these physical differences and although they certainly can vary within a wide spectrum – individuals are different too – I don't think that the difference will ever be obliterated. That's my opinion based on my observations and I could be wrong. I suppose that we will find out, if the present trend continues, just how far it goes before it begins to cycle back on itself – and that will be very interesting!

MM: *Well, that is more or less all I can ask you right now.*

JK: Do have fun, you ask very stimulating questions!

MM: *Thank you! The difficulty is I am very much interested in the long term programmes, but there is no way of getting close to them right now.*

JK: I've put you off every time, you know! The reason is, my agency is putting off the long range pictures.

MM: *I see the point and appreciate it since you make these things real and there is no other way.*

JK: We need people planning for the future, too! Maybe we need more than we have right now in this area? But we have to climb that mountain first, to get back into space!

MM: *Dr. Kerwin, thank you very much!*

REFERENCE

1. Mario Mutschlechner, 'Living in Space American Style: An Interview with Joseph Kerwin, M.D.,' *Spaceflight*, **20**, 8, August 1978, pp. 307-309.

SHUTTLE BOOSTER DEVELOPMENT

The Space Shuttle's solid rocket motor, largest of its type ever built for manned space flight, has successfully completed a series of four developmental static firings.

The final static firing was completed on 17 February at the test site in northern Utah near Brigham City. During the two-minute firing, the motor's thrust level reached a peak of about 13,000,000 Newtons (3,000,000 lbf). The system which gimbals the motor nozzle, for guidance during flight, was operated over the most severe duty cycle expected to be experienced in flight.

NASA officials in charge of the project reported that test objectives were fulfilled and that preparations would begin immediately for a series of three qualification test firings.

The qualification firing tests, which began this spring, will qualify the motor for use in the first manned flight of the Space Shuttle and will demonstrate the production, assembly and firing cycle to support a full schedule of Shuttle flights.

More that 35 metres (115 ft) long and 3.5 metres (12 ft) in diameter, the motor is assembled from four segments. For actual flights, the segments will be transported separately and assembled at the launch site.

Two of the motors will be used on each Shuttle. During a launch, the motors will operate for about two minutes and will be separated on burnout at an altitude of about 43.5 km (27 miles). A parachute recovery system will lower them into the ocean where they will be recovered for re-use.

SPACE REPORT

A regular monthly review of Space Events and Technical Trends

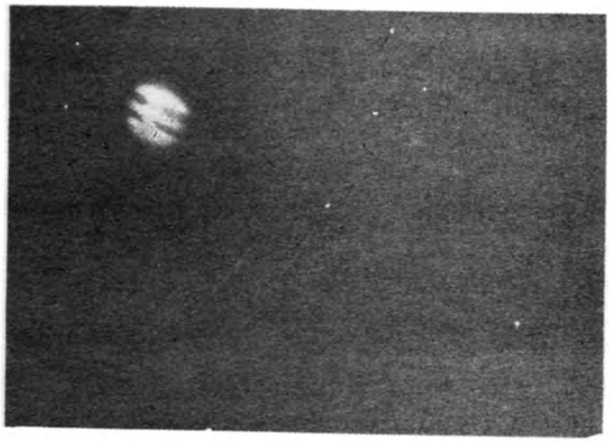
TRIUMPH OF VOYAGER

The wealth of new information about Jupiter and its major moons received from the Voyager 1 spacecraft has astonished even the project scientists at JPL. As the craft drew nearer the giant planet, the cameras showed increasing detail. The circulation patterns became more discernible. Much attention was focussed on the Red Spot itself to determine its wave pattern – is the centre swirling while the edges are quiet, or is the centre quiet while the edges flow?

Now known to be purely an atmospheric feature, the Red Spot was once thought to be anchored to a surface feature, which would have explained its longevity. Its size has decreased in recent years.

Increasing detail in the belts (dark bands) and zones (light bands) also show interesting features. The zones are thought to be rising, while the belts are descending. At their interfaces, wind shears result, accounting for the turbulent features observed in these areas.

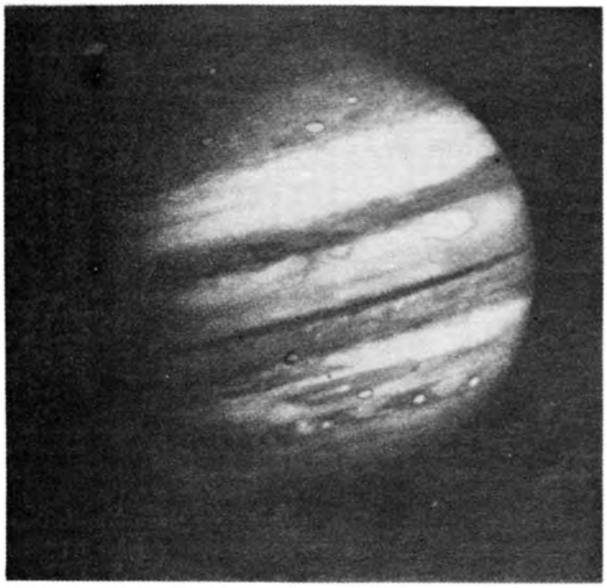
'Hot spots' can be seen below the Red Spot, to the left and right. Specific spacecraft sequences were targeted to these and other interesting features. In these pages we begin a picture series on the Jupiter encounter which reached its climax on 5 March.



JUPITER IN LONG-SHOT. This photograph of Jupiter and three of its Galilean moons was taken by Voyager 2 as long ago as February 1978 when the spacecraft was 437 million kilometres from the planet. North is towards the top with the satellite Europa at left. Io and Ganymede are seen at right.

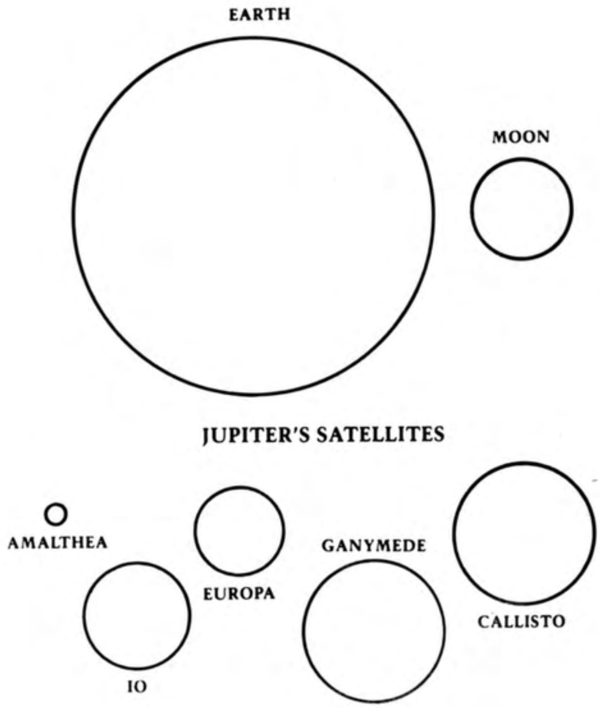
All photographs Jet Propulsion Laboratory, NASA

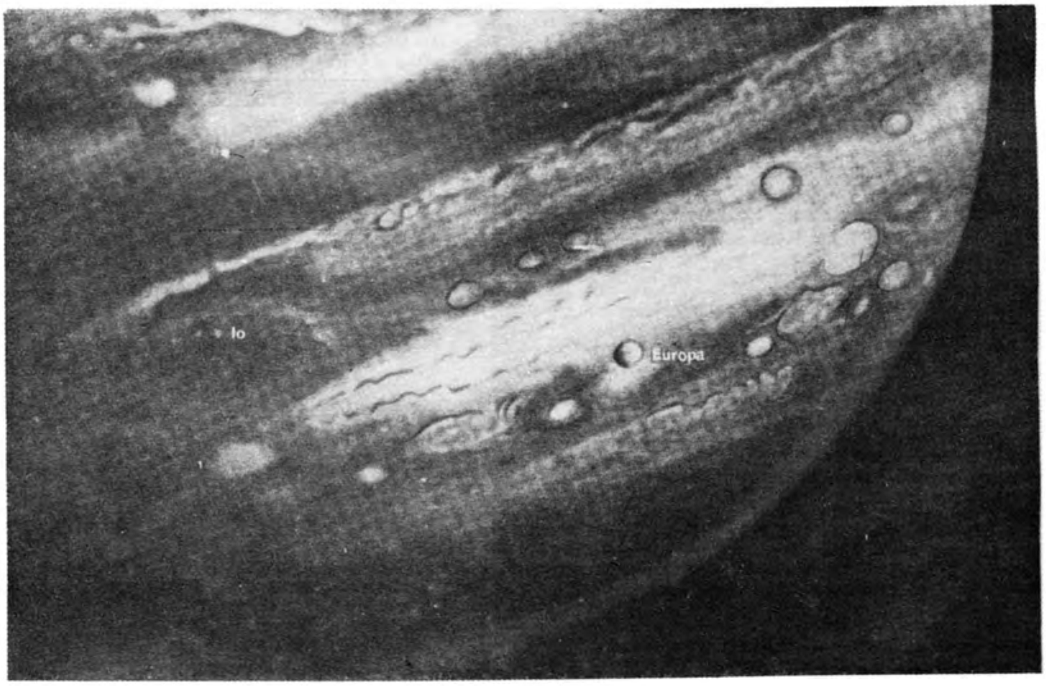
Jupiter from Voyager 1 on 9 January 1979 is dominated by the Great Red Spot. Although the spacecraft is still 54 million kilometres from the 5 March closest approach, the spacecraft's cameras already reveal details within the spot which are not visible from Earth. Swirling, storm-like features possibly associated with wind shear can be seen both to the left and above the Red Spot (see also picture on page 258).



MOONS OF JUPITER. Io poses before the giant planet in this photo returned 17 January 1979, from a distance of 47 million kilometres (29 million miles). The satellite's shadow can be seen falling on the face of Jupiter at left. Io is travelling from left to right in its 1¾ day orbit.

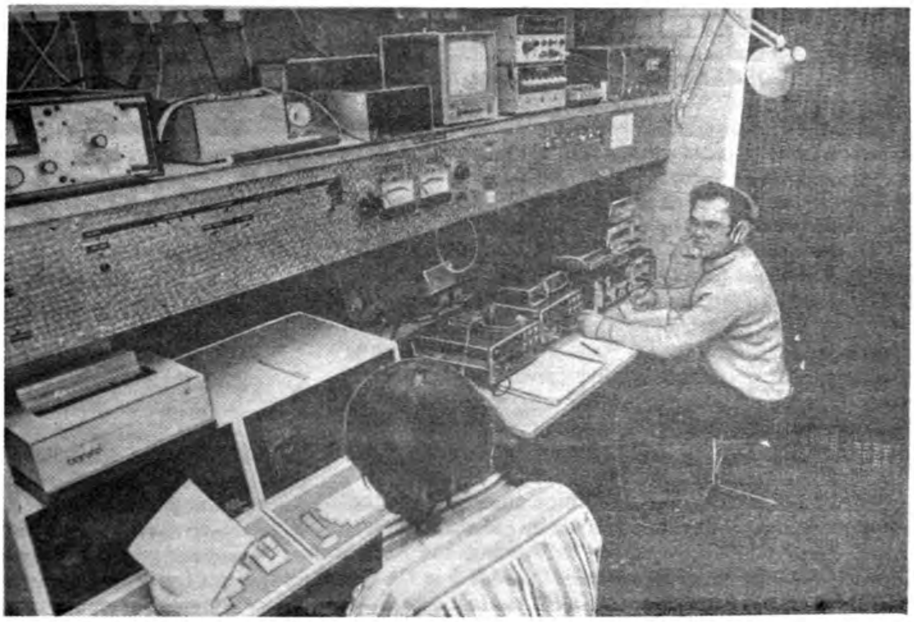
All pictures JPL, National Aeronautics and Space Administration





CLOSING IN. Voyager 1 took this photo of Jupiter, Io, and Europa on 13 February 1979. Io is about 350,000 kilometres (220,000 miles) above Jupiter's Great Red Spot, while Europa is about 600,000 kilometres (275,000 miles) above Jupiter's clouds. Although both satellites have about the same brightness, Io's colour is very different from Europa's. Io's equatorial region shows two types of material – dark orange, broken by several bright spots – producing a mottled appearance. The poles are darker and reddish. Preliminary evidence suggests colour variations within and between the polar regions. Io's surface composition is unknown, but it may be a mixture of salts and sulphur. Europa is less strongly coloured, although still relatively dark at short wavelengths. Markings on Europa are less evident than on the other satellites, although this picture shows darker regions toward the trailing half of the visible disk. Jupiter was about 20 million kilometres (12.4 million miles) from the spacecraft at the time of this photo. At this resolution (about 400 kilometres or 250 miles) there is evidence of circular motion in Jupiter's atmosphere. While the dominant large-scale motions are west-to-east, small-scale movement includes eddy-like circulation within and between the bands.

Next Month: At Close Encounter



Command station of the University of Surrey's Electronics and Amateur Radio Society (EARS). It is the only known station in the world to have been set up and run by students and since 1974 has commanded successive amateur radio satellites in the OSCAR series while they are passing over Europe. Martin Sweeting (right) is Project Co-ordinator for the new British amateur space satellite (UOSAT).

Audio-Visual Aids Unit, University of Surrey

BRITAIN'S FIRST AMATEUR SATELLITE

Britain's first amateur space satellite is to be built at the University of Surrey. The project is being co-ordinated by the Telecommunications Research Group within, and supported by, the Department of Electronic and Electrical Engineering. It is being carried out in close collaboration with the University's Electronics and Amateur Radio Society (EARS), the international Amateur Satellite Corporation (AMSAT), the Amateur Satellite Organisation of the UK (AMSAT-UK) and the Radio Society of Great Britain. Active support is being given by Britain's electronics, telecommunications and space industries.

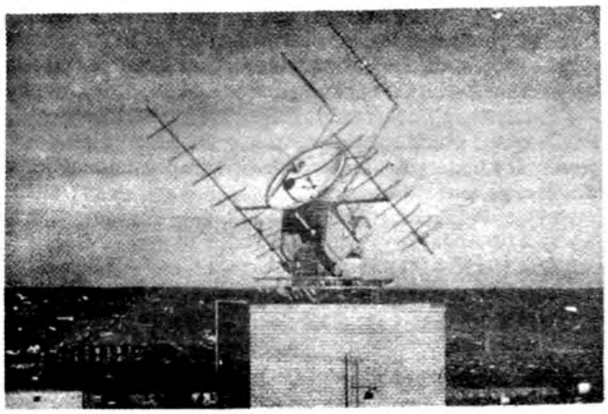
AMSAT has been responsible for eight previous amateur satellites in the OSCAR series (Orbiting Satellites Carrying Amateur Radio). These have been built internationally by radio amateurs in the USA, Germany, Canada, Japan and Australia, and their function has been to relay VHF and UHF radio signals, extending the range of transmissions by amateur radio enthusiasts. Each has been given a 'piggy-back' launch by NASA when space was available in launch vehicles, because of their educational value.

The new satellite will be Britain's first contribution in flight hardware to the Amateur Space Programme. Its purpose and proposed features are a departure from the OSCAR series. First, it provides an opportunity for gaining practical experience in developing an inexpensive UK spacecraft programme. Second, its main feature is to be a series of high-frequency beacons, enabling radio amateurs all over the world to study the changing effects of the ionosphere on radio-wave propagation. Third, it is intended to stimulate a greater practical interest in the space sciences in schools, colleges and universities.

The project will be co-ordinated at the University and much of the spacecraft will be built there. It will be constructed in modular form, priority being given to the power, telecommand and other fundamental service systems, followed by the high-frequency beacons. Several other, more complex, experiments are planned, and these will be undertaken later at the University or by other amateur groups in this country until resources, including time, run out.

The design, construction and testing of the satellite will take about two years. It is intended for a polar orbit at a height of 900 km, and a possible launch opportunity exists early in 1981.

Below, aerial complex of the command station, capable of tracking satellites to an accuracy of 0.5 deg. The two metre (6.56 ft) paraboloid and tracking mount were donated by the Admiralty after being no longer needed for experimental work. The tracking mount was originally part of a Bofors anti-aircraft gun.



The cost of the satellite is expected to be around £150,000, and support for the project is being provided in cash and kind by a number of organisations, including:

Amatuer Satellite Corporation (AMSAT); Amateur Satellite Organisation of the United Kingdom (AMSAT-UK); Appleton Laboratories; British Aerospace; Ferranti; Marconi Space and Defence Systems; M.E.L.; Philips Research Laboratories; The Post Office; Racal; The Radio Society of Great Britain, and The Royal Aircraft Establishment.

Surrey University's involvement in satellite work has developed as a result of the interest and ability of its student Electronics and Amateur Radio Society (EARS). Since 1974 EARS has played an increasing role in commanding satellites of the OSCAR series. These satellites contain VHF and UHF receivers and transmitters and are intended for use by radio amateurs to extend the range over which their transmissions are received, in the same way as

television programmes are relayed around the world.

The early OSCAR satellites were monitored and controlled by a command station in the USA, but in 1974 a new satellite, OSCAR-6, developed a fault after launch which resulted in it switching off (or on) when least expected. To counteract this, extra command stations were set up in Canada and Australia, but there was no European station and indiscriminate use of OSCAR-6 by European radio enthusiasts when it should have been switched off was in danger of draining the batteries.

To counteract this, EARS set up a command station using a simple aerial system. With the support of the Department of Electronic and Electrical Engineering and of a number of industrial companies, the EARS command station (still the only one in the world set up and run by students) now possesses a sophisticated steerable aerial system, capable of tracking satellites to an accuracy of 0.5° and designed to monitor and command satellites automatically. The station has largely been responsible for substantially extending the life of OSCAR-6 and from 1974 to 1977 issued some six million commands to the satellite, making it available for use by radio amateurs from Iceland and Norway down to Morocco and Jugoslavia.

Following the eventual death of OSCAR-6 in December 1977, EARS has been responsible for control over Europe of OSCAR-7, now four years old and beginning to develop telemetry faults. On 5 March this year it played a major part in the launching of OSCAR-8, involving transatlantic radio and telephone links with the Goddard Space Flight Centre and amateur radio stations in Europe, and use of the University's main computer to analyse orbit parameters and telemetry from the satellite, prior to assuming its role as the European Command Station. The station also receives data from weather satellites.

The success of the station would never have been possible without the facilities, encouragement and support given by the University's Department of Electronic and Electrical Engineering, which rightly sees it as a valuable training ground for undergraduates in satellite telecommunications work.

ELECTRIC FIELD EXPERIMENT

The Space Plasma Physics Division of ESA's Space Science Department has been involved in development and building of an electric field experiment in cooperation with Dr. I. Zhulin of IZMIRAN, Moscow. IZMIRAN is an institute belonging to the Academy of Sciences of the USSR involved in studies of the Earth's ionosphere and magnetosphere.

This cooperative effort was started in April 1976 and experiment hardware was built during 1976/77 based on the Division's experience with electric field probes and electronics made for the GEOS satellite.

Instruments subsequently were installed on the Magik satellite launched on 24 October 1978 into a near polar 83° inclination orbit with apogee of 775 km and perigee of 409 km.

The first data samples which have been received from IZMIRAN indicate that all parts of the experiment are working very well. The measured parameters are three components of the quasi-static electric field and two components of electric plasma waves up to 5 kHz.

The European Space Agency points out that the electric field data from Magik and GEOS combined will provide opportunities for understanding energy flow between the magnetosphere and ionosphere which previously did not exist.

CONDITIONS ON VENUS

New information on the formation of the inner planets, an explanation of the seaping hell like conditions on Venus and observations of what may be strange chemical fires on the surface of the planet are amongst the early results from the Pioneer Venus mission, writes John Davies.

Pioneer found several hundred times more primordial argon and neon on Venus than on Earth, which has in turn far more than the planet Mars. These results may require revision of current theories of planetary formation, since if the young Sun had, as previously believed, swept away the lighter gases hydrogen and helium it should also have depleted the argon and neon. However the opposite is observed argon and neon increase going in towards the Sun, suggesting that the original solar nebular may have been heated evenly allowing the gases to gravitationally concentrate towards the centre. Gases adsorbed on dust partides would be incorporated into the protoplanets, or even into the fully formed planets themselves, before the Sun heated up and swept the Solar System clear of the remaining gases.

Mariner 10 ultra violet photographs suggested the existence of global atmospheric patterns on Venus and these are confirmed by the Pioneer orbiter. Air rises around the equator and decends again in the polar regions, above 60 degrees lattitude. Paradoxically the atmosphere above the polar cloud is about 10°C warmer than over the equator. Temperature variation between the day and night sides of the planet's atmosphere differ only by 1 or 2°C, showing the efficiency with which the high speed winds distribute the incoming solar radiation. At about 70° lattitude a wide ring of colder higher clouds circle the poles and at a temperature of -58°C they are about 50° colder than the hottest polar cloud tops.

From the day probe the following details of the atmospheric structure were revealed. The probe passed the bow shock wave about 8000 km out (of Earth 65,000 km) and found the region down to the ionosphere at 400 km turbulent with temperatures around 1 million degrees C, many times higher than comparable temperatures at Earth. Magnetic fields, induced in the ionosphere by the relative motion of the solar wind, holds off the solar wind at least as strongly as the Earth's magnetosphere. Unlike Earth's, the Venusian ionosphere is confined below a well defined boundary called the ionopause. Pioneer orbiter observed a rise of over 1000 km in the ionopause as the solar wind dropped from 500 km/sec to 250 km/sec before it was crushed back to 250 km when a solar flare increased the solar wind to 600 km/sec.

At 250 km the probe encountered the sensible atmosphere with a density of 10^{-15} gm/cc and a temperature of 27°C, and then passed the exobase, the bottom of the region from which molecules escape directly into space, at 160 km. Maximum ion density occurs at 145 km, the most abundant ions being O_2^+ and CO_2^+ although O^+ predominates at higher altitudes. Nearly coincident with the ion density maximum is the turbopause, the boundary below which atmospheric gases are uniformly mixed by their kinetic motion rather then being layered according to density. At 125 km the atmospheric density is 10^{-10} gm cc and the first layer of clouds is still 50 km below. At 100 km the temperature drops to 93°C but rises again to 13°C on entering the first cloud layer at 65 km altitude.

About 8 km thick this proves to be more of a haze cloud, consisting of sulphuric acid particles in the 1 to 2 micron range. At 66 km the Sun is starting to dim and 3 km later it is no longer discernable as a disc, although horizontal visibility if 6 km. The second cloud layer, also 8 km thick, starts at 56 km and contains more sulphuric acid, solid particles of elemental sulphur in the 10 to 15 micron range and 4 micron particles which appear to be liquid. At this

level the temperature has risen to 20°C and the pressure is approaching one Earth atmosphere. The final layer between 49.5 and 47.5 km is opaque enough to resemble Earth type clouds and contains mainly 10 to 15 micron particles of solid and liquid sulphur with a few smaller particles of sulphuric acid. The temperature here is 202°C, around the melting point of sulphur. A pre-cloud layer, a few hundred metres thick, exists below the clouds, and is followed by a haze of submicron particles, probably sulphuric acid, to a height of 30 km. From here to the surface the atmosphere is completely clear.

The temperature rises rapidly, from 310°C at 30 km, 380°C at 80 km to 410°C at 10 km, and the final 10 km of the atmosphere appear to be circulating convectively.

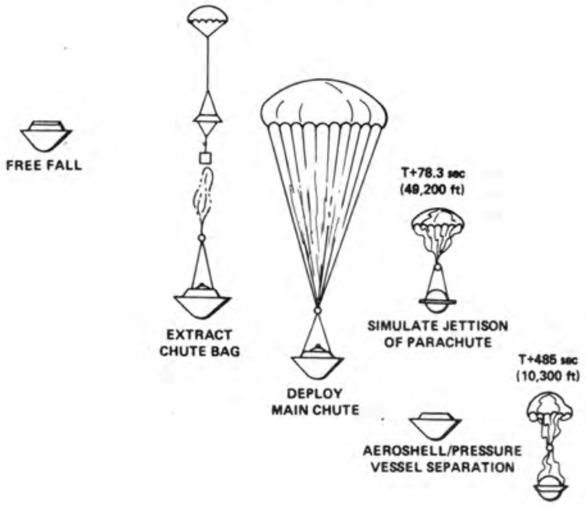
The night side probes observed strange glows on or near the surface from 13 km altitude, but experimenters are looking into the possibility that these were due to the intensly heated surfaces of the probes themselves.

From 7 km high the surface would appear below, but because of light scattered by the thick atmosphere visibility is only 12 km and the illumination a gloomy red.

Impact occurred at a speed of 35 km/hr and threw up dust which took 3 minutes to settle. Surface temperature is 450°C, pressure 91 atm, and with only 10% of non-reflected light reaching the surface it is not possible to locate the Sun in the sky. Exceeding expectations, the day probe survived 67 minutes on the surface before signalling the end of America's first Venus landing mission.

The writer would like to thank staff of the Jet Propulsion Laboratory and Ames Research Center, NASA, for information used in this summary report.

DEPLOYMENT AND SEPARATION SEQUENCE



Venus probes.

TEST STANDS MAY AID 'QUAKE RESEARCH

Rocket test stands developed in the 1960's may be given a new role in research on earthquake hazards, writes Dave Dooling. A three-day workshop at Marshall Space Flight Center in Huntsville, Alabama, in February concluded with the belief that the stands there could make a major contribution to the earthquake hazards mitigation programme.

"I think it's surprising to many of us to see what's here," said Dr. John Blume, president of the Earthquake Engineering Research Institute. "It's like walking into a goldmine of everything you've been hoping to have for 40 years."

Marshall's test facilities are unmatched anywhere in the world. It has static test stands for rocket engines – ranging in size to one capable of holding the 7.5 million pounds of thrust produced by the Saturn 5 first stage – and structural and vibration test stands. Earlier this year they were still being used for load and launch vibration tests on the Space Shuttle. But after these are completed, there are no major test programmes.

In 1978, federal officials had already began investigating the possibility of using the Marshall stands to study how buildings hold up under earthquakes, and how designs might be modified.

"We are not going into the earthquake business," Dr. George McDonough of Marshall told the workshop. "We are trying to make available – to people with that responsibility – whatever we have."

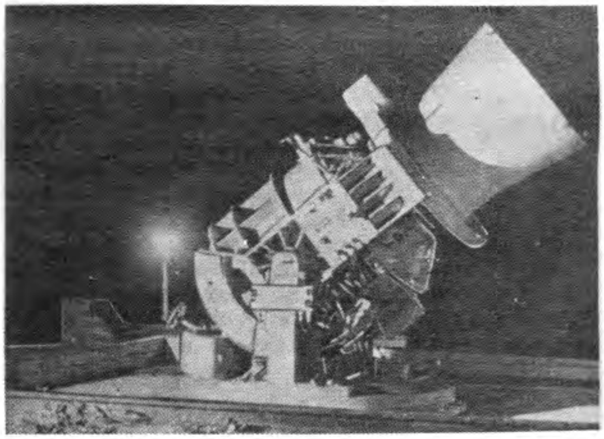
Participants in the workshop came from several federal agencies, universities and institutions. They seemed to be equally impressed with the data handling capabilities as much as the size of the test facilities. Some of the test areas can handle as many as 2,000 channels of data on a single test.

"There's no doubt that the facilities here and the capabilities are unmatched in the country or even the world," said Dr. John Scalzi of the National Science Foundation, co-host for the workshop.

Major areas addressed in the workshop were soils, structures, and soil-structure interaction. Also discussed was the possibility of doing soil research aboard Spacelab. Soil under the extreme pressures of earthquakes will often behave as a fluid. Placing soils in low gravity may lead to a better understanding of this phenomena.

"(This) is very important to the engineering profession interested in seismic problems," Scalzi said. "Extending this work to a zero-gravity environment has the potential of advancing the frontiers of knowledge in the fields of soil mechanics and soil-structure problems.

"The problem of liquefaction of soils is an important phenomena in seismic events, and from all indications, very little is known of this behaviour. A complete study involving zero-gravity combined with terrestrial studies of multiple-gravity effects is required before design recommendations can be made."



SPACE 'EYE'. One of the two Hewitt Cameras donated to the University of Aston by the Ordnance Survey for use in satellite tracking (*Spaceflight*, March 1979, p. 139). This camera is sited near Pershore, Worcestershire; the other, originally in Edinburgh, has been sent to Australia where it should be operational this autumn.

University of Aston

$1,900 MILLION SHUTTLE CONTRACT

Rockwell International Corporation has received a $1,900 million production contract from NASA to build and modify four Space Shuttle spacecraft. The new cost-plus-award fee contract authorises the construction of two new Space Shuttle orbiters and modification of two existing spacecraft to meet operational mission requirements in NASA's space transportation system for the 1980's.

Rockwell is prime contractor for the Space Shuttle orbiter and its main engines and is integrator of the overall Space Shuttle system. The new contract is an extension of the original Space Shuttle contract awarded in 1972, when the company was selected to design, develop, test and evaluate two orbiter spacecraft and a structural test article.

Under the terms of the contract, Rockwell will perform the work on the four orbiter spacecraft at its space systems group facilities in Downey and Palmdale, California. The names of the four spacecraft assigned to operational missions are "Columbia," "Challenger," "Discovery" and "Atlantis."

"Columbia" was transported from Rockwell's Palmdale facility to Kennedy Space Center in March for pre-launch testing and close-out prior to being launched into near-Earth orbit on the first space transportation system mission late this year.

"Challenger" is the structural test article currently undergoing limit load tests at Palmdale. This complete orbiter spacecraft structure will be returned to the Rockwell site later this summer for modification and systems installation. It will be the second orbiter to be launched on orbital missions.

"Discovery" and "Atlantis" are in initial phases of long-leadtime procurement and detailed fabrication. These spacecraft will be in final assembly and pre-launch status during 1983.

The first Space Shuttle orbiter "Enterprise" successfully completed the approach and landing test programme in 1977 and recently completed mated ground vibration testing at NASA's Marshall Space Flight Center in Alabama. The "Enterprise" will be used as a "test bed" for development of operational capabilities and systems development.

INTEGRAL ROCKET/RAMJET TESTING

Work has begun on the world's most advanced integral rocket/ramjet (IRR) test facility to increase its capacity to simulate ramjet flights at supersonic speeds and up to 16 miles altitude, according to Alphonse Peters, manager of Ramjet Programs at the Chemical Systems Division of United Technologies. The expansion of the multi-million dollar facility includes major additions of computer hardware for complete test monitoring and the construction of a second IRR test complex.

An integral rocket/ramjet is a jet propulsion engine which employs an internal solid rocket booster motor to reach supersonic speed, then, through a series of inflight mechanical changes, operates as a ramjet to reach higher velocities, increased operating efficiencies and greater range.

The Chemical Systems Division's growing ramjet facility, located at CSD's 5,500 acre Coyote Center, 23 miles (37 km) south of its Sunnyvale, California, headquarters, is the only known test site of its kind designed to specifically handle IRR systems.

CSD engineers use computer-controlled equipment to put IRRs of new design through simulated preprogrammed flight tests. Turns, dives and climbs are simulated as well as temperatures, altitudes and cruising speeds. Hundreds of sensors monitor the ramjet as it "flies" at sea level and "soars" to 83,000 ft (25,300 m) altitude at 2,790 mph (4,490 km/h) (about Mach 4). The new test complex will enable engineers to increase simulated speeds up to approximately Mach 6 (4,200 mph – 6,758 km/h).

With the recent installation of increased memory computer hardware, test engineers will be able to review almost instantaneously on readout sheets how the missile and its engine performed internally and externally under the varied test conditions. The addition of over 100 recording channels has increased the system's capability to monitor over 300 test parameters and will give test personnel an even more complete picture of simulated test flights. A complex system of cables, pipes, valves, boilers and pumps provides air, steam, heat, pressure and jet fuel to simulate every conceivable flight pattern and condition.

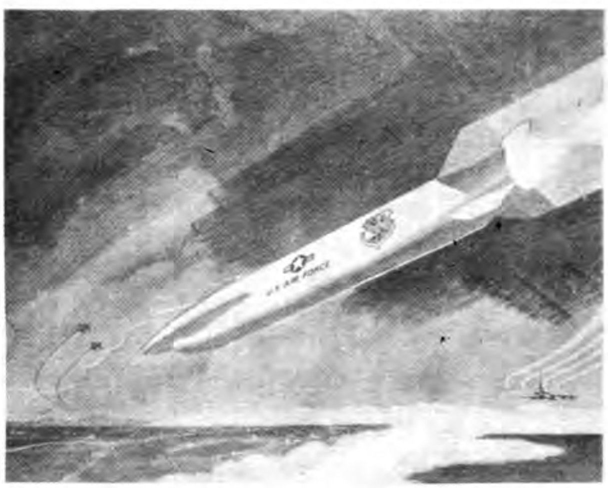
The heart of the altitude simulation system, for example, is two giant 45,000 and 30,000 gallon hot water steam accumulators, 90 ft (27.4 m) long and 10 ft (3.05 m) in diameter. These accumulators generate steam up to 400°F

COSMOS NAVSAT FAILURE

The unique 83°, 98.7 min, 965 – 424 km orbit of Cosmos 1064, launched on 20 December 1978, immediately raised suspicions of an in-orbit failure to circularise and provide the 105 min circular orbit characteristic of the Russian navigation satellite system, writes Geoff Perry of the Kettering Group.

Investigation of the position of its orbital plane at launch showed that it was 1.56° ahead of that of Cosmos 991, suggesting that Cosmos 1064 was intended as a replacement for Cosmos 991 in the system of six satellites with a 30° plane-spacing. This hypothesis gained strength when Cosmos 1072 was launched on 16 January into a plane 1.65° ahead of Cosmos 991.

With Chris Wood, Geoff has shown that the Russian navigation satellites are further identified by a number in the range from 1 to 8 which may be determined by decoding the telemetry. Cosmos 991 (5) was still operational in mid-January and its replacement, Cosmos 1072, had been given the identity number 8. Decoding of telemetry received at Oxted on 19 January showed that Cosmos 1064 was also operational and had been given the number 1.



Artist's impression of the Advanced Strategic Air-Launched Missile (ASALM).

United Technologies

and pressures of 250 psi (17.6 kg/cm^2) to simulate altitudes up to 16 miles (26 km).

Workmen at Coyote have dug a vast network of trenches for the underground pipes that will bring all the necessary fuel, heat and air components to the second IRR test stand. Construction has begun on this second test complex, which will enable CSD engineers to greatly increase their testing of new ramjet propulsion systems. Like its sister stand, the new test cell will "float" on moveable pads so the exact thrust of the motor can be measured.

Since 1972, CSD has been conducting extensive research and development of ramjet propulsion systems with support from United Technologies Research Center and its Hamilton Standard Division. CSD has been awarded a number of major ramjet propulsion projects, including the development of an Advanced Strategic Air-Launched Missile (ASALM) for the U.S. Air Force, the Supersonic Tactical Missile (STM) for the U.S. Navy and Vought Corporation, and the Air Force-Navy solid fuel ramjet (SFRJ).

PAM FOR INDIA

Two Payload Assist Module (PAM) rocket systems have been ordered by the Ford Aerospace and Communications Corporation to help launch satellites the company is developing for the Government of India.

McDonnell Douglas Astronautics Company of Huntington Beach, California, will build the PAM systems to boost the INSAT weather and communications satellites into geosynchronous transfer orbits from the cargo bay of the Space Shuttle vehicle in low Earth orbit.

The Ford Aerospace order, valued in excess of $6 million, covers two PAM vehicles, payload integration tasks and launch support services. It provides for options on later decisions to launch the Indian satellites on Delta boosters if shuttle flight plans do not meet Indian Government schedule needs. The PAM will be delivered to Ford Aerospace and Communications to support launch dates in 1981.

The Ford Aerospace order is the third PAM sale announced by McDonnell Douglas; an order for six PAM systems for Hughes Aircraft Company was announced on 8 November last, and NASA earlier ordered six PAM vehicles.

McDonnell Douglas is developing the PAM to provide satellite operators in the 1980s and beyond with a vehicle to lift payloads to higher orbits after the Shuttle carries them into near-Earth space. As many as four satellites, with PAM stages attached, could be launched in a single flight of the re-usable Orbiter.

The PAM can serve also as an upper stage on a conventional McDonnell Douglas/NASA Delta expendable launch vehicle. Satellite operators can choose either the shuttle or a Delta as their booster with minimal lead-time and modification requirements, giving flexibility in planning missions during the early years of shuttle operations.

Two models of PAM are being developed by McDonnell Douglas as privately funded commercial space vehicles. The Ford and Hughes orders are for PAM-D systems, designed as secondary booster for payloads up to 2,750 lb (1,245 kg). NASA ordered the more powerful PAM-A, designed for payloads as heavy as 4,400 lb (1996 kg) now launched by Atlas-class rockets.

CASTING INCOMPATIBLE ALLOYS

Once again space researchers are showing the way into a new industrial age. Metallurgists at NASA's Marshall Space Flight Center who have been preparing zero-gravity processing experiments for Spacelab have found a new method of alloy casting which can be practiced on Earth. An electrical wire that offers little or no resistance to current is just one of hundreds of beneficial products that could stem from their discovery.

DR. MARY HELEN JOHNSTON checks the sample container for a 'Dendrite Remelting and Macrosegregation in Zero-Gravity Casting' experiment launched aboard a sounding rocket. She recently played a leading part in the new casting method with incompatible alloys at the MSFC Materials and Process Laboratory.

Dr. Mary Helen Johnston and Richard A. Parr of Marshall's Materials and Processes Laboratory explain that the new casting method is a result of research with immiscibility gap materials, which do not mix naturally. "An example," says Dr. Johnston, "is lead and aluminium. Such products as superconductive wire, bearings and improved magnets could be made from an aluminium-lead alloy. These two materials can be mixed in a molten state but as they begin to cool and solidify the aluminium and lead will separate."

There are several hundred possibilities for applying the new process to control the structure of immiscible materials during casting, according to Dr. Johnston. "It could open up a whole new range of alloys that we have never been able to produce before."

The controlled structure is achieved by adding a small amount of impurities to the alloy materials during the melting process, and applying a rapid cooling from one end of the cast. In the case of aluminium and lead castings, the impurities cause the aluminium to form a hexagonal cell structure as it cools and the lead finds its way into the little valleys formed by the hexagons. These tiny particles of lead are trapped in the valleys and become uniformly dispersed throughout the casting.

"This is a breakthrough of major technical significance;" said Robert Schwinghamer, director of the Materials and Processes Laboratory. "Based on our research to date, it appears that the method is generally applicable, is economical to apply, and can be used to produce particles of the secondary alloy material in the shape of spheres or rods, with controlled size and spacing."

Dr. Johnston believes that the implications of this breakthrough extend far beyond the possibility of producing novel composites for structural application. She points out that "there are hundreds of alloy systems with liquid miscibility gaps about which little is known because metallurgists have traditionally been unable to render them in useful forms. Many of the alloys will have unique and desirable electrical characteristics. There are so many possibilities that our problem now is choosing the way to go from here."

SATELLITE DIGEST - 127

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed summary of the information presented can be found in the January, 1979 issue, p. 41.

Continued from May issue.

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/origin
ECS (Ayame) 1979-9A 11261	1979 Feb 6.365 indefinite	Cylinder 260	1.5 long 1 dia	190	34583	24.09	607.16	Tanegashima N-1 Japan/Japan (1)
Cosmos 1075 1979-10A 11262	1979 Feb 8.41 2 years?	Cylinder? 1000?	3 long? 1.5 dia?	428	516	65.83	94.51	Plesetsk C-1 USSR/USSR
Cosmos 1076 1979-11A 11266	1979 Feb 12.54 60 years	Cylinder? 1000?	3 long? 1.5 dia?	635	664	82.53	97.78	Plesetsk C-1 USSR/USSR (2)
Cosmos 1077 1979-12A 11268	1979 Feb 13.90 60 years	Cylinder + 2 panels? 2500?	5 long? 1.5 dia?	623	630	81.23	97.30	Plesetsk A-1 USSR/USSR
SAGE 1979-13A 11270	1979 Feb 18.679 40 years	Hexagonal prism + booms 147	1.62 long 0.8 dia	549	661	54.93	96.73	WTR Scout NASA/NASA (3)
CORSA (Hakucho) 1979-14A 11272	1979 Feb 21.208 30 years	Cylinder 100	0.5 long 1 dia	541	573	29.90	95.61	Tanegashima Mu-3C Japan/Japan (4)
Ekran 3 1979-15A	1979 Feb 21.33 indefinite	Cylinder + 2 paddles + antenna array 2000?	5 long? 2 dia?					Tyuratam D-1-E USSR/USSR (5)
Cosmos 1078 1979-16A 11276	1979 Feb 22.51 8 days (R) 1979 Mar 2	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	168	280	72.85	89.01	Plesetsk A-2 USSR/USSR (6)
Solwind 1979-17A 11278	1979 Feb 24.35 40 years?			562	600	97.66	96.36	WTR Scout DoD/USAF (7)
Soyuz 32 1979-18A 11281	1979 Feb 25.496	Sphere + cone-cylinder + antennae 6600?	7.5 long 2.2 dia	193 240 296	256 280 307	51.59 51.64 51.63	88.93 89.65 90.49	Tyuratam A-2 USSR/USSR (8)
Cosmos 1079 1979-19A 11283	1979 Feb 27.62	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	171	337	67.14	89.61	Plesetsk A-2 USSR/USSR (9)
Intercosmos 19 1979-20A 11285	1979 Feb 27.71 100 years	Ellipsoid + panels? 550?	2 long? 1.5 dia?	500	990	73.98	99.75	Plesetsk C-1 USSR/USSR (10)

Supplementary notes:

(1) Japanese built and launched experimental communication satellite.

(2) Environmental satellite studying the oceans and their associated physical processes.

(3) SAGE stands for Stratospheric Aerosol and Gas Experiment. The satellite is designed to study dust and liquid droplets in the upper atmosphere by measuring their filtering effect on sunlight.

(4) Japanese scientific satellite studying the soft X-ray region of the spectrum.

(5) Domestic TV relay satellite, carrying television broadcasts to remote regions of the USSR.

(6) Manoeuvrable reconnassaince satellite, an object designated 1979-16C separated from it during March 1 which may have been the manoeuvring engine.

(7) USAF research satellite (ionosphere and magnetosphere).

(8) Manned spacecraft carrying crew to the Salyut 6 orbital station. Crew commander Lt. Col. Vladimir Lyakhov was accompanied by civilian flight engineer Valery Ryumin, who was involved in the unsuccessful docking attempt by Soyuz 25 during 1977. Soyuz 32 docked at 1330 UT on Feb 26 and the crew entered Salyut about three hours later to begin the programme of re-activating and checking over the spacecraft systems.

(9) Experimental satellite carrying equipment from Bulgaria. Czechoslovakia, Poland, Hungary and the USSR. Its purpose is to supplement the ionospheric and magnetospheric studies of Intercosmos 18 and Magion (1978-99A and C).

Amendments

Three objects, one of which may have been a supplementary payload separated from 1979-1A during 1979 Jan 19.

The Editor is always interested in receiving correspondence for publication. Letters should be as concise as possible. Some slight shortening of the text may be necessary, on occasions, owing to limitations of space,etc.

STUDY COURSE

THEME: THE ORIGIN AND EVOLUTION OF THE UNIVERSE

A course of six evening lectures will be given on the above topic during the 1979/80 session. Details are as follows:

Chairman: A. T. Lawton

3 October 1979	The Primordial Fire Ball by Dr. I. Robson
7 November 1979	Quasars and Seyfert Galaxies by Dr. R. F. Carswell
5 December 1979	The Extragalactic Distance Scale by Dr. D. A. Hanes
2 January 1980	The Evolution of Stellar Systems by Dr. J. Jones
23 January 1980	X-Rays in the Universe by Dr. A. C. Fabian
20 February 1980	Future Observations in Cosmology by Dr. C. D. Mackay
5 March 1980 (provisional)	The Microwave Background: Relic of the Big Bang? By Dr. M. Rowan-Robinson

Course fee: £5.

The Venue will be the Golovine Conference Room at the Society's Headquarters, 27/29 South Lambeth Road, London, SW8 1SZ, England.

For further details and application forms apply to the Executive Secretary of the Society.

16th EUROPEAN SPACE SYMPOSIUM

The BIS has long been associated with its sister Societies in Europe (DGLR, AAAF and AIDAA) in holding international meetings directly concerned with promoting and fostering European participation in Space.

At the IAF Congress in Dubrovnik, the four Societies agreed to reconvene these meetings on an enhanced basis and to seek even greater participation from the European Scientific and Technical Communities.

Our Call for Papers appeared last month and is repeated below.

Theme: **CURRENT AND POTENTIAL EUROPEAN SPACE PROJECTS**

To be held in Stresa, Northern Italy, on 3-5 July 1979, co-sponsered jointly by the DGLR, AAAS, AIDAA and BIS.

Technical Sessions will be devoted to the following main subject areas:

(1) Spacelab and Supporting Activities

(2) Technology of Space Vehicles (Satellites and Launchers)

(3) Space Applications

(4) Future Trends

Please bring this to the attention of all your colleagues who ought to know about this Meeting and who might wish to submit Papers or to attend and take part in the discussions.

Details of the programme and other arrangements will be published as soon as these have been completed. Please contact the Executive Secretary for further information.

VIII IFAC SYMPOSIUM: AUTOMATIC CONTROL IN SPACE

Oxford, UK 2-6 July 1979

Sponsored by: International Federation of Automatic Control (IFAC).

Organised by: The Institute of Measurement and Control on behalf of the United Kingdom Automatic Control Council (UKAC) and co-sponsored by The British Interplanetary Society.

Topics

The IFAC Space Committee is concerned with the areas of:

Automatic control
Open and closed loop control and stabilisation
Man-in-the-loop control
Remote control
Combinations of these modes

in space and space related investigations and applications of which some specific fields are:

Space launch and landing systems
Spacecraft and satellites (including rendezvous problems)
Space laboratories and telescopes
Aerospace systems
Planetary and earth/space related surface systems
Use of spacecraft and terrestrial navigation
Underwater systems
Inertial systems for underwater positioning
Manipulators, tele-operators
Space experiments
Navigation, guidance and control systems (including components such as sensors, effectors and power control)

Copies of the full Programme and Registration Forms are available from the Executive Secretary, British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ, England.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London, SW8 1SZ.

Correspondence and manuscripts intended for publication should be addressed to the Editor 27/29 South Lambeth Road, London, SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

VIII IFAC International Symposium

Theme: **AUTOMATIC CONTROL IN SPACE**

Sponsored by the International Federation of Automatic Control: Organised by The Institute of Measurement and Control on behalf of the U.K. Automatic Control Council and co-sponsored by The British Interplanetary Society.

To be held in Oxford, **2-6 July 1979.**

Copies of the Programme and Registration Forms may be obtained from the Executive Secretary of the Society.

16th European Space Symposium

Theme: **CURRENT AND POTENTIAL EUROPEAN SPACE PROJECTS**

To be held in Stresa, Northern Italy, on **3-5 July 1979**, co-sponsored jointly by the DGLR, AAAS, AIDAA and BIS.

Members planning to attend should advise the Executive Secretary.

Please contact the Executive Secretary for further information, Programmes and Registration forms will be available on request in due course.

Special Honours Meeting

The Society's Bronze Medal will be presented to Captain Robert F. Freitag, Deputy Director, Advanced Programs, Office of Space Transportation Systems, NASA at a special meeting to be held in the Auditorium of the American Embassy (Upper Brook Street Entrance) London, W.1. on **16 July 1979,** 3.30-5.30 p.m.

Captain Freitag will address members after the presentation ceremony.

Admission will be by ticket only. Applicants should apply to the Executive Secretary enclosing a reply-paid envelope.

Informal Talk

Title: **AN EVENING WITH ARTHUR C. CLARKE**

To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **28 August 1979**, 7.00-9.00 p.m.

Admission tickets are not required. Members may introduce guests.

3rd BIS CONFERENCE ON INTERSTELLAR STUDIES

The Conference will be held in the Chemistry Lecture Theatre, University College, London, W.C.1. on **11-12 September 1979.**

Applications for registration forms and notifications of the intention to submit a paper for the Conference should be made to the Executive Secretary of the Society.

34th ANNUAL GENERAL MEETING

The 34th Annual General Meeting of the Society will be held in the Tudor Room, Caxton Hall, Caxton Street, London, S.W.1. on **13 September 1979,** 7.00 p.m.

A detailed Agenda will appear in *Spaceflight* shortly.

Nominations are invited for election to the Council. Forms can be obtained from the Executive Secretary. These should be completed and returned not later than **20 June 1979.**

Should the number of Nominations exceed the number of vacancies, election will be by postal ballot. Voting papers will then be prepared and circulated to all members.

30th IAF Congress

The 30th Congress of the International Astronautical Federation will be held in the Deutsches Museum, Munich, Germany from **17-22 September 1979.**

Theme: **SPACE DEVELOPMENTS FOR THE FUTURE OF MANKIND**

Details of the technical sessions were listed on page 176 of the April issue of *Spaceflight*. Members wishing to present papers and requiring further information are asked to contact the Executive Secretary.

A particular invitation has been extended for papers to be presented at the Student Sessions of the Congress: these must be submitted through an IAF Member-Society.

BIS members, both from the U.K. and overseas, who plan to attend the Congress are asked to notify the Executive Secretary accordingly.

Lecture

Title: **BEYOND SATURN** by Dr. G. E. Hunt.

To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **9 October 1979**, 7.00-9.00 p.m.

Admission tickets are not required. Members may introduce guests.

3rd Computer & Space Technology Conference

Theme: **IMAGE PROCESSING TECHNIQUES APPLIED TO ASTRONOMY & SPACE RESEARCH**

To be held at the SRC Appleton Laboratory, Ditton Park, Slough, Bucks on **15-16 November 1979.**

Topics will include:

a) Astronomical Image Processing

b) Planetary Imaging

c) Remote Sensing

d) Interactive Processing and System Design

e) Applications of Array Processors

f) Image Restoration

Offers of papers (including a 300-500 word abstract of the proposed paper) should be sent to the BIS Executive Secretary, 27/29 South Lambeth Road, London, SW8 1SZ, England.

Lecture

Title: **THE INTERNATIONAL SOLAR POLAR MISSION**

by D. Eaton (ISPM Project Manager)

To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **21 November 1979,** 7.00-9.00 p.m.

Admission tickets are not required. Members may introduce guests.

PLEASE NOTE OUR NEW ADDRESS

As from *1 May 1979* the Society's address changed to *27/29 South Lambeth Road, London, SW8 1SZ.*

Correspondents should ensure that all future communications are sent to this address.

Our new telephone number will be advised shortly.

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VISIT TO PERME

Reported by L. J. Carter

Introduction

Icy conditions prevailed to reduce the numbers in the party in the PERME visit on 14 February 1979, but those who did manage to overcome rail ice-ups, 'go-slows' on the Circle line and similar impediments, were all well rewarded.

The PERME Establishment (probably still more widely known under its old name of the Rocket Propulsion Establishment) is situated on the A41 between Aylesbury and Bicester (Fig. 1). Although some of the party braved the elements in their own transport, most went by British Rail from Marylebone to Aylesbury, where they were picked up at the station by coach for onward transit.

The morning session was basically one of Briefing, beginning with the welcome from Mr. R. Heron the Deputy Director who sketched out the role and position of PERME.

History of the Westcott Establishment

British interest in rocket technology was stimulated, at the end of World War II, with the awareness of German achievements in this field. It led to the formation of the Ministry of Supply in 1946, controlling the Guided Projective Establishment, responsible for research and development in ground-launched guided missiles. GPE was set up at Westcott – then a disused RAF base, thus enabling many of the original buildings to be used, after conversion, to provide workshops, specialised facilities, etc. Large test sites for static testing of complete missiles were also constructed. In line with German practice, early research was concentrated on liquid bi-propellant rocket engines, with sections on fuel supply, combustion chamber design, instrumentation, etc.

In 1947 the Establishment changed its name to the Rocket Propulsion Department of the Royal Aircraft Establishment: its terms of reference were also narrowed to include only the propulsion aspects of rockets, work on all other aspects being transferred to the Guided Weapons Department of the RAE.

Work began on solid propellant motors in 1949. To satisfy the need for new motor filling techniques created by the use of new plastic propellants, an experimental filling factory was instigated in 1950 and completed in 1952. A significant contribution to Britain's Upper Atmosphere Research Programme then was the development of the Raven motor, containing one ton of plastic propellant and used extensively in the Skylark Upper Atmosphere Research rocket.

As rocket motor technology developed, so too did the need for supporting research, particularly in materials, chemistry, and the physical and chemical studies of combustion processes. In 1951, for example, a Combustion and Materials Division was formed.

In 1955 Rolls Royce contracted to build the RZ1 liquid-propellant engine using liquid oxygen and kerosine to provide propulsion for Blue Streak. Testing of these engines required improved facilities as well as new measuring and recording equipment. To meet this need the P2 Site was prepared and tests started in 1958. By 1960 some 500 firings had been made.

The link with RAE was severed in August 1958 and the name of the Establishment changed to the Rocket Propulsion Establishment. Several major building projects were subsequently completed, including a new Administration Building in 1968 and a new Materials Laboratory shortly afterwards.

In 1971, in accordance with the recommendations of the White Paper on Government Organisation for Defence Procurement and Civil Aerospace, the RPE became the responsibility of the Procurement Executive of the Ministry of Defence. As part of the rationalisation of defence research establishments it was merged with its sister establishment, the Explosives Research and Development Establishment (ERDE), Waltham Abbey in January 1973, with one Director responsible for the unified Establishment. Further rationalisation was effected in 1975 by the transfer of the Rocket Motor Executive to Westcott. In 1976 the posts of Director ERDR/RPE and Head of RME were combined.

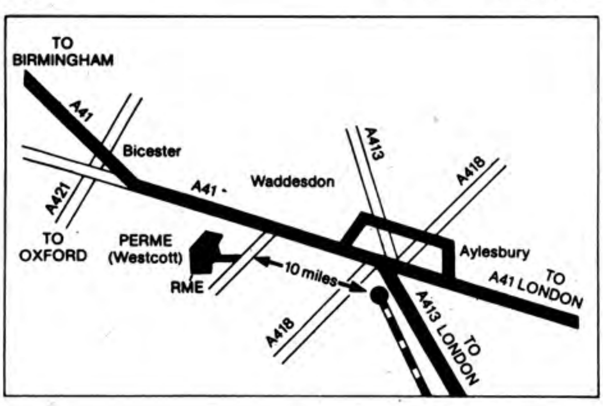
In February 1977 ERDE/RPE – against a background of some 30 years in the development of more than 500 different rocket motors – was re-named the Propellants, Explosives and Rocket Motor Establishment (PERME).

PERME Today

The Propellants, Explosives and Rocket Motor Establishment (PERME) is one of the larger of the twelve research and development establishments within the Procurement Executive, Ministry of Defence.

The establishment consists of two main units approximately 52 miles apart, with a smaller unit at Woolwich. One unit is located at Waltham Abbey, Essex, 16 miles north-east of London and othe other at Westcott, Aylesbury, Buckinghamshire, 50 miles north-west of London. The Westcott site occupies an area of 623 acres and employs a staff of about 700. The Rocket Motor Executive (RME), set up to coordinate and exploit UK rocket motor capabilities

Fig. 1. *All illustr. Crown Copyright*



PERME Westcott view of Main Administration Block, Design Office, Drawing Office, Liquid Motors Division.

in the commercial market – with some 25 staff, is also located at Westcott.

PERME is responsible for a programme of research, exploratory development, project development, and in some areas, production, in the fields of

a) rocket propulsion, covering rocket motors, rocket propellants, power cartridges and gas generation systems for auxiliary power units;

b) gun and small arms propellants, and

c) initiatory explosives.

PERME's work on rocket propulsion is supported mainly by Bristol Aerojet Limited which undertakes research, design, development and production of rocket motor bodies, nozzles and other components, and by Royal Ordnance Factories which carry out propellant manufacture and filling, igniter filling and the production of rocket motor hardware. In the rocket propulsion field, only one other organisation, IMI Summerfield (a Government Agency factory which is managed by Imperial Metal Industries Limited* on behalf of the Procurement Executive) undertakes overall design, development and testing of rocket motors. IMI Summerfield undertakes research, and develops and manufactures solid propellant rocket motors using the cast double base propellant system.

Present Work

Present work at Westcott – concentrated on rocket motors, gas generators and power cartridges – is carried out in three operating Divisions, *viz*:-

(a) *Solid Propellant Rocket Motors Division*
This Division is responsible for the design and development of solid propellant rocket motors, gas generators and power cartridges for military and civil applications. Work extends from the period from initial conception through development and production to 'in service' surveillance throughout the life of the rocket motor.
The Division is also responsible for developing motor filling procedures and specifying these to the Royal Ordnance Factory responsible for production filling. Extramural support is provided mainly by Bristol Aerojet Limited and by various Royal Ordnance Factories.
Although the Division is mainly engaged in development work some effort is deployed on research.

(b) *Liquid Propellant Rocket Motor Division*
This undertakes design, development and research on rocket motors utilising packageable liquid propellants, such as inhibited red fuming nitric acid as oxidant, and mixed amine fuels, which can be sealed into tanks, ready for instant use but storable for the whole life of the missile. Packaged liquid propellant motors are used in military applications where control of thrust on command is necessary. This feature demands a high degree of mechanical complexity, requiring components such as control valves, pistons, etc.
The Division is also responsible for the development of special handling procedures necessary for the propellants, for tank filling procedures and in-service training and surveillance.

(c) *Chemistry and Applied Physics Division*
This Division, working towards the progressive improvement of overall rocket motor performance, contributes to most aspects of rocket technology; materials and techniques of construction; methods of proving quality and performance; integrity of propellant charges; liquid propellants and their containment; motor functioning and the rocket exhaust plume. In all of these the emphasis is on research, though some routine testing and analysis are performed.

This was followed by a presentation from Mr. H. Williams, Deputy Director of the Rocket Motor Executive (RME) who described the role of his Group which was set up in the mid-1970's to provide a commercial interface between missile Prime Contractors (British Aerospace, Short Brothers, Hunting Engineering) or foreign Customers and system controllers of the three services.

The third speaker was Dr. R. C. Parkinson who took as his theme the problems of solid propellant rocket motors, ranging from the smallest, the Imp, with 50 grams of propellant and used for separation units, spin motors, etc., to the largest 1 metre in diameter and which uses about 5 tons of propellant. Burning times range over periods from only a few tens of milliseconds to 300 seconds.

In total, units are provided with total impulses of 100,000 to 1 or burning times of 20,000 to 1.

Particularly interesting was the family tree of propellants (Table 1) which fell in two main groups, i.e.:-

(a) Double-based, e.g. nitroglycerine and nitrocellulose.

(b) Composite, i.e. ammonium perchlorate (a crystalline powder) as main oxidiser, and with a binder material as the fuel.

Table 1. Solid Propellant "Family Tree"

Solid Propellants

Double Base	Composite
= Nitrocellulose + Nitroglycerine + Catalysts	=Ammonium Perchlorate + Aluminium + Binder + Catalysts

Extruded Double Base	Cast Double Base	Composite Modified	Rubbery (Cast)	Plastic (Pressed)

Low performance	High performance
Low density	High density
No smoke	Primary and secondary smoke
Platonized burning rate	ap^n burning rate
Low temperature coefficient	High temperature coefficient
Loose charges	Case bonded charges
Long life	Long life

Composite propellants are inclined to be very smoky whereas double-based propellants are extensively used where no smoke at all is desired.

* *PERME and IMI Summerfield, with their supporting resources, represent the entire rocket motor design, development and production capabilities in the United Kingdom. No independent industrial capabilities now exist in the UK.*

Also described were the variety of rocket charges, ranging from cigarette burning charges as the simplest to complex radial burning shapes. The Cuckoo, Goldfinch and Raven motors were shown, all used on the Skylark Sounding Rocket (perhaps the most successful of all such vehicles) and are a family of motors standardised at 17" in diameter and using radial burning plastic propellant for high performance. The highest performance motor developed at Westcott was Waxwing, used as the apogee motor for the Black Arrow, an all-British satellite launcher.

Among the interesting incidental information was a statement that the reaction principle, invariably credited to Newton, was actually proposed by John Wallis twenty years earlier, as the Law of the Conservation of Momentum.

The talk concluded with a description of some of the work being done in using high-strength steel and carbon fibre rocket motor cases.

Dr. G. Cook introduced the topic of Liquid Rocket Motors by mentioning that PERME was now the only Group remaining in the UK devoted to this topic, though is currently working on guided weapons, it being some years since space work was conducted. A particular area of interest concerned the storability of liquid propellants, with the aim of producing units which can be hermetically sealed and kept for (say) up to 10 years at a time without further maintenance. The layout of liquid propellant motors, both pump-fed and gas-fed, were fully explained, the talk being followed by a film called "Development of a Packaged Liquid Propellant Test Vehicle" which described the work done over the last 10 years, including test launches from Aberporth, over Cardigan Bay, and from Eskmeals in Cumbria.

A most interesting area of rocket technology, i.e. of rocket "Plumes", was then described by Dr. D. Jensen.

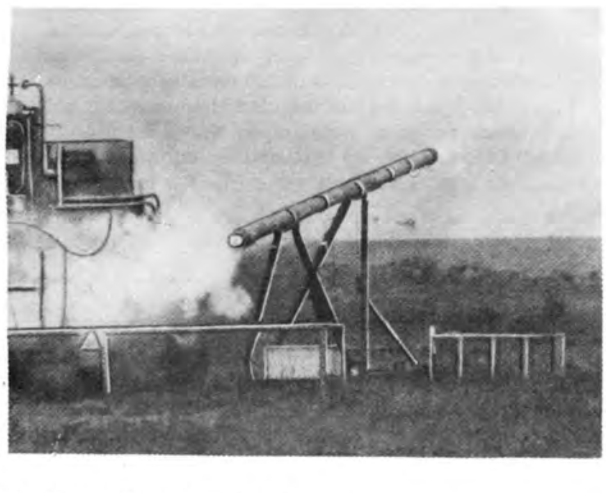
The rocket exhaust plume, i.e. the flame and smoke trail that follows in a rocket's wake, is determined by many factors, e.g. type of ignition, propellant used, the shape of the nozzle – all of which speak volumes about the rocket actually producing it.

PERME is concerned with ways to assess, measure and predict the exhaust plume, a vital factor for rocket guidance, detection and tracking.

After the problem of smoke, flash, light and radio attenuation, come the problems of the exhaust flame itself. This should have low smoke or infra-red detection characteristics, besides contributing minimum interference with the guidance and tracking signals, and, apart from all this, should not produce any adverse effects on the users!

Sir William Congreve

There are many problems involved in analysing flame structures but this is important to obtain the greatest thrust, bearing in mind the turbulent nature of the fuel-rich flame as it leaves the exhaust both during combustion and during mixing with the surrounding atmosphere.



Liquid propellant recoilless gun.

Exhibits

After lunch, the group went to see the static exhibition of PERME work, covering solid and liquid propellant rocket motors, ignition, material structures and non-destructive testing, the event being greatly enhanced by the presence of a number of PERME scientists and engineers to describe and explain the exhibits in detail.

The first section, on Rocket History, consisted of a number of paintings and an original Congreve rocket. This was followed by a series on rocket fundamentals, particularly on early liquid motors, including exhibits of the Sprite and Scorpion ATO units. An interesting sidelight on this work concerned the flight of an early solid test rocket, which, half way up the ascent, took a sharp right-hand turn and vanished, to the despair of those wishing to recover it again.

The next day some fishermen appeared to ask "Do you want your rocket back?" It had been caught in their net so they were very put out about it. Fortunately, the vehicle was recovered almost intact and provided ample evidence of the cause of the malfunction.

Solid propellant rocket motors for missiles systems Sea Wolf, Sea Skua, and the space research Skylark rocket, were

exhibited. On the liquid propellant rocket side was the Packaged Liquid System Test Vehicle (PLTV) a field of technology pioneered by PERME Westcott.

The Chemistry and Applied Physics Section included examples of Plume technology studies, instrumentation and materials, the latter including samples of carbon fibre and flow-formed rocket motor cases made of maraging steel which, incidentally, gave a most enchanting and incredibly long-lasting chime when struck by the finger!

Some of the equipment on the instrumentation side was extremely interesting, with a console operating to indicate the applications of a binary system to various test situations.

An intriguing small calculator also had a most discerning nature. When pressed into use, it was able to calculate that the author had, so far, lived a total of 20,791 days. Someone must exist, somewhere, interested in that information.

Solid Propellant Rocket Firing

Solid Rocket Firing

The last of the visits was to K2 Site, to see a large solid propellant rocket motor firing. The vehicle selected for static test was a straightforward boost motor with a plastic (composite) propellant used on the Bloodhound missile.

To meet the occasion, the group were fitted out with hard white helmets and inspected the vehicle on the site. The actual motor was built in August 1966 and was on the horizontal test stand for checking out its characteristics after a decade. The unit had an offset nozzle, to direct the exhaust away from the missile on launch, though pit-marks on the walls indicated that the direction had not always been that most desired.

The party then went to look at the Control Room, in small groups, the last batch staying behind while the earlier groups braved the biting wind and driving snow to witness the "big bang" itself. The rocket fired for three seconds, the performance then being abruptly curtailed as the whole place vanished in smoke, thus bringing out the point made earlier in the discussions about the need for propellants which burn with minimum smoke.

Those in the Control Room were honoured by being provided with a 10 second countdown, specially laid on for the occasion.

BOOK REVIEWS

The Nature and Origin of Meteorites
By D. W. Sears, Adam Hilger Limited, 1978, pp. 187, £13.50.

This is a well illustrated hardcover book which would be a welcome addition to any library. It summarises the present 'state of the art' of meteorite study. The author intends the book for use by undergraduate and research students and while it would be most suitable as such, I felt that it would also be quite readable by any interested layman.

The initial chapter is based on historical aspects of research into meteorite phenomena. This is pleasant, easy and interesting reading covering events from finds in the middle ages to the present day. Improvements are discussed in scientific investigation techniques from the introduction of thin sections and microscopic investigation to modern gas analysis, spectroscopic and radioactive analysis methods. The various methods of meteorite classification are covered along with the historical significance associated with each classification system.

The second chapter describes the highly dramatic fall of meteorites to Earth and the craters which have occasionally resulted. Good photographic illustration throughout the book leave the reader with some vivid impressions. Associated sounds, caused by sonic booms, and light emissions as the meteorite falls through the atmosphere are examined.

The next three chapters cover in more detail the classification, mineralogy, petrology, compositional properties and physical properties of meteorites. Here the layman can omit the more detailed formulae and still gain an understanding and insight into detailed meteorite study. The chapter describing physical properties and processes contains a detailed study of radiogenic investigation methods and this is well presented descriptively and mathematically.

The final chapter summarises the most important data and examines the possible origin of meteorites. Using radiogenic experimental methods the formation age of meteorites can be determined and this has been found to be 4.6×10^9 years. This represents one piece of evidence for the age of the Solar System, assuming of course that the meteorites were formed from the original primordial solar nebula. This seems likely because the relative proportions of various elemental isotopes are much the same in terrestrial, lunar and meteoritic samples. Further studies of meteorites have been designed to determine how long a meteorite has been exposed to cosmic radiation. This is called the exposure age of the meteorite and this is considerably lower than the formation age, typically 10^7 years. This implies that meteorites originally belonged to larger parent objects which later became fragmented by collision. It is possible that these larger objects had a diameter of the order of 300 km and there were very few of them. The origin of meteorites has always been a controversial topic, but it now seems most likely that they are derived from the short period comets or the main belt asteroids.

This is altogether a well presented and enjoyable book to read. It has an excellent bibliography which is cross referenced throughout the text, and is therefore ideally suited for students wishing to study any particular topic in greater depth.

JOHN S. BURY

PANEL OF REVIEWERS

The Council wishes to expand the Society's Panel of Reviewers, particularly in the areas of technical works on all aspects of space and specialised topics in astronomy. Members with appropriate qualifications willing to contribute Reviews of this nature are invited to write to the Executive Secretary for further information.

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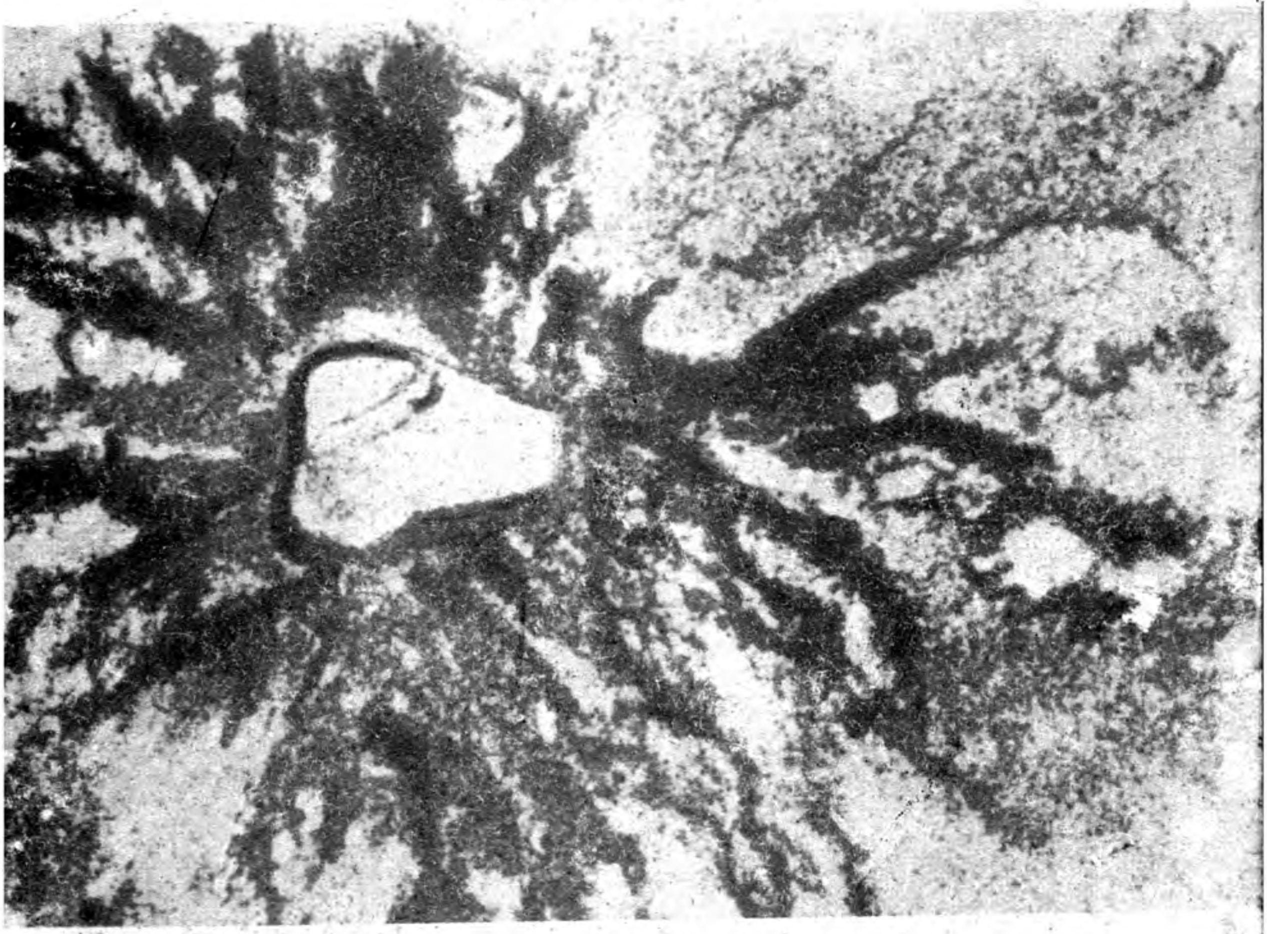

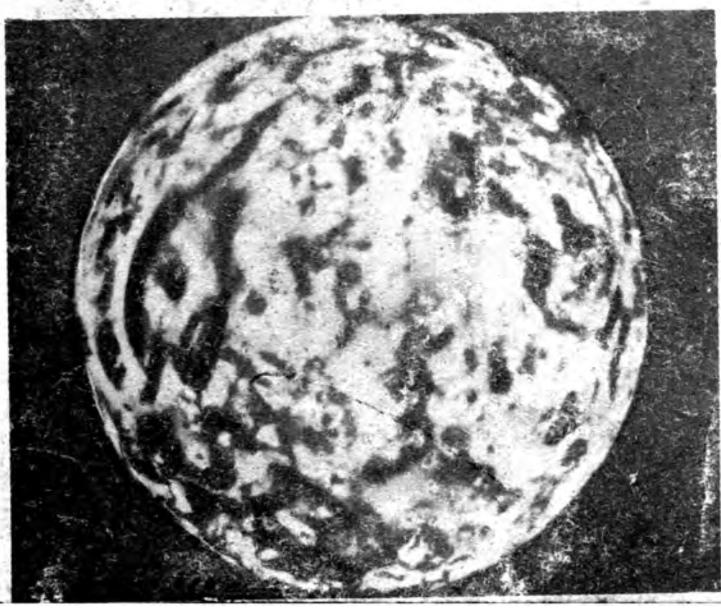

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SPACEFLIGHT

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Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

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COVER

VOLCANIC MOON. From 30,800 km the Voyager 1 camera looks down on an irregularly shaped composite crater on Io about 50 km across with dark flows radiating from its rim. The crater is a volcanic caldera and the dark flows are probably low viscosity lavas possibly of basaltic origin. *Below left*, this remarkable four picture mosaic of Io was taken from a distance of 496,000 km. The diameter of Io is 3,640 km, slightly bigger than Earth's Moon. *Right*, an active volcano on Io with plume-like ejecta rising more than 100 km into space.

National Aeronautics and Space Administration, JPL

MILESTONES

March

27 Preliminary Flight Certification (FC) of Space Shuttle Main Engine begins at National Space Technology Laboratories, Bay St. Louis, Mississippi. Firing lasted planned 520 sec simulating a typical flight profile.

29 British Aerospace Dynamics Group at Bristol, leading a team of European specialists, completes £120,000 study of the payload for a proposed Earth Resources Survey Satellite System for ESA. Remote sensors would provide data on: coastal sedimentation and pollution; conservation and use of fish stocks; ship routing, making use of ocean currents; data on wave forces for use in the design of offshore structures and wave power generating systems; mapping of polar ice caps, ocean temperatures and winds for improved climate and weather forecasting.

29 NASA and ESA sign agreement for joint International Solar Polar Mission (ISPM) to be launched in 1983 from Space Shuttle by Inertial Upper Stage (IUS). NASA and ESA will each provide a spacecraft to observe the Sun for the first time from the perspective above the polar regions. The two spacecraft will swing around Jupiter and use the gravity of that body to redirect their paths out of the ecliptic plane towards the Sun in trajectories – one northbound and one southbound – that are essentially mirror images of each other.

30 Orbit of the Soyuz 32/Salyut 6/Progress 5 complex is raised by means of thrust from Progress 5. Parameters are now 284-357 km by 51.6 deg x 90.6 min.

April

1 Reports from Moscow indicate that cosmonauts Vladimir Lyakhov and Valeri Ryunov had to carry out a major repair of the Salyut propellant system. The entire complex of Soyuz 32/Salyut 6/Progress 5 was made to revolve about the common centre of gravity as part of the difficult task of emptying and cleaning one of the space station's tanks which had developed a defect. First indication of trouble appeared just before the previous crew vacated the station. This proved to be a perforation in the bladder separating the nitrogen gas used to expel the fuel from the tank from the fuel itself. It was decided that the new crew should take the tank out of commission. Part of the fuel was transferred to the other two tanks in Salyut 6 and most of the remainder to an empty tank aboard Progress 5. The valves of the tank were then opened to space and the tank flushed out with nitrogen.

2 Orbit of Salyut 6 is adjusted by engines of Progress 5.

3 Progress 5 is separated from Salyut 6 at 19 hrs 10 min (Moscow time).

4 Soviet cosmonauts checkout operation of the onboard sub-millimetre telescope BST-1M and calibrate the UV channel.

5 Progress 5 burns up as planned over the Pacific Ocean.

5 Academician Boris Petrov, vice-president of USSR Academy of Sciences and chairman of Intercosmos Council, says 10th five year plan period will "continue the exploration of outer space, expand investigation into the use of space facilities for the study of Earth's natural resources, in meteorology, oceanography, navigation, communications, and for other needs of the national economy. The Soyuz-Salyut complex is an excellent base for multipurpose observations and for long-distance probing of our planet. The results of such studies are needed by geologists

[Continued overleaf

irrigators, workers in agriculture and are used in survey work, for instance, in laying oil and gas pipelines which link West Siberia and the European part of the USSR. The results of space investigations are also used in designing a number of hydro-power stations and for seismic zoning in civil and industrial construction. The photographs made by Salyut 6 go to more than 400 organisations where they are used by thousands of scientists, engineers and specialists, and it is hardly possible to calculate the great economic effect that space studies have had for the national economy."

6 Salyut 6 cosmonauts complete another experiment in the Kristall furnace devoted to studying processes of diffusion during melting and subsequent cooling of metal alloys (tin-lead and aluminium-copper) in joint programme with France. Ampoules of materials for study were brought to the station in Progress 5.

6 Orbit of Salyut 6 is adjusted by propulsion unit of Cosmos 32.

7 Salyut 6 cosmonauts begin two more experiments in Kristall furnace. Object is to study "various materials under micro-gravity conditions: semi-conductors and metallic components having magnetic properties."

10 Shuttle Orbiter 'Enterprise' is flown from Marshall Space Flight Center to Kennedy Space Center on Boeing 747 mother. The ground test vehicle – to be used for compatibility testing – will be stacked on mobile launcher and rolled out to Launch Complex 39A.

10 Soviets launch Soyuz 33 from Tyuratam cosmodrome at 20.34 hrs (Moscow time) with Soviet cosmonaut Nikolai Rukavishnikov, flight commander, and Bulgarian research cosmonaut Major Georgi Ivanov. Ivanov graduated from the Aviation School with the qualification of engineer-pilot in 1964. He served in the Bulgarian Air Force as flight commander and squadron leader. He entered the Yuri Gagarin Cosmonauts' Training Centre only in March 1978.

11 Orbit of Soyuz 33 following initial manoeuvres, by revolution 13, is 273 x 330 km x 51.6 deg. But cosmonauts fail to dock with Salyut 6 when, at 21.54 hrs (Moscow time), a propulsion unit used to align the craft with the space station "was found to be deviating from the normal." Mission is recalled.

12 Soyuz 33 cosmonauts soft-land in darkness at 19.35 hrs (Moscow time) some 320 km south east of Dzhezkazgan.

12 Report from Bulgaria suggests that an attempt will be made to mate rats aboard the next Soviet Cosmos bio-satellite to be flown later this year. The experiment involves "several pairs of rats in special cages." The results "will serve to assess... how space flights may influence man and his progeny." Responsible agencies are the Radiology and Radiobiology Institute at the Medical Academy in Sofia and the Aeromedical Institute.

14 *Soviet Weekly* reports that the Soviet Union is ready to launch India's second satellite as soon as tests of the flight model are complete. Soviet specialists have flown to Bangalore, South India, to take part in the tests. The satellite for Earth Observation (SEO) is designed to study the Earth from space in the interests of the Indian economy (see page 300). The USSR is providing the launch vehicle, launch facility and other services free of charge. Indian specialists also have access to the Bear Lake ground station for controlling the initial part of the flight and monitoring data.

14 *Soviet Weekly* reports that the original programme of satellite launchings under Intercosmos, drawn up in 1967, is near its end. A new programme to cover the years 1981-1985 is under discussion.

BIS DEVELOPMENT PROGRAMME

OUR NEW SPECIALISED SPACE LIBRARY

Arrangements for the Society to set up a new specialised space library are now well under way. The bookracks are being made ready and we shall soon start to acquire, as economically as possible, a store of books to provide the best sources of information we can muster.

Our collection will feature current Technical Reports, specialised books and reference material on space research and technology, astronomy, and closely-related items such as space law, exobiology, etc.

The Council seeks help from all members, both in the U.K. and overseas, who would like to support us in this work by donating suitable books, reports and other items, for the Society would also like to receive photographs, films, recordings, paintings, models – in fact, any similar space-related publications or small artifacts, especially those likely to be of lasting value and which might form the basis for building up an Archive Collection.

In view of the need to keep room available for later growth, it is regretted that collections of periodicals, popular books on astronomy or space, books not specifically related to our interests, or general books in foreign languages, cannot be accepted. In view of the requirement to build up a "balanced" collection, members wishing to donate items are asked, in the first instance, to send details to the Executive Secretary, who is responsible for co-ordinating this part of the Society's Development Programme.

'ONE GIANT LEAP' - 10 YEARS AFTER!

"The U.S. programme to explore outer space produced some of the most outstanding technical achievements the world has ever known. I hope our technological success will benefit people the world over."

Andrew Young, U.S. Ambassador to the United Nations

"We're divided among arbitrary geographical lines, separated into ethnic categories, and divided along various linguistic groups, but when we look at Earth and the human species from a few hundred miles up, we can't help but sense the oneness of the human race."

Jerry Brown, Governor of California

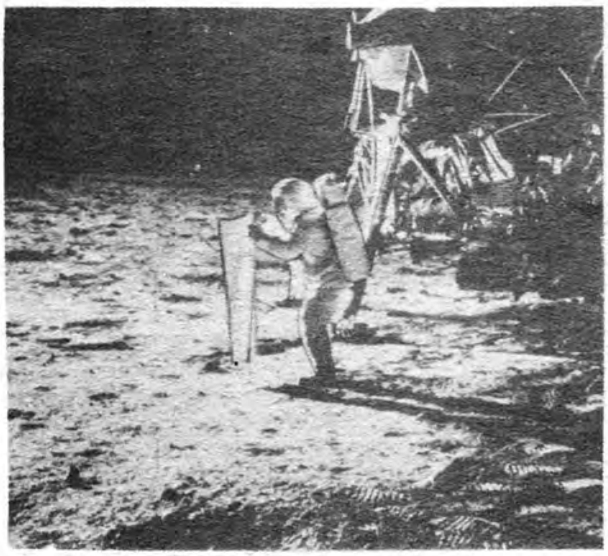
"I'm interested in what the space programme *will* mean to people. We are entering the Shuttle era, which can bring the benefits of space back to Earth. Our challenge is to seize this opportunity and make it a reality."

Senator Adlai E. Stevenson (D-Illinois), Chairman of the Senate Subcommittee on Science, Technology and Transportation

Michael Collins, Apollo 11 CSM Pilot, who took Neil Armstrong and Edwin Aldrin on the world's greatest voyage of discovery – 16-24 July 1969.

Neil A. Armstrong

Edwin E. Aldrin, Jr.



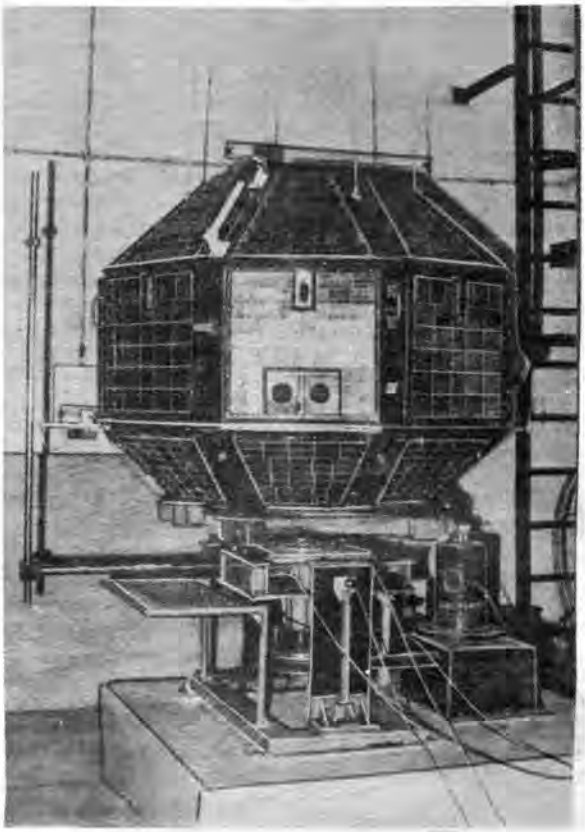
FOOTPRINTS ON THE MOON. Apollo 11 astronaut Edwin Aldrin deploys the Solar Wind Composition Experiment on the surface of the Moon in this picture taken by Neil Armstrong. The two men made their historic visit on 20-21 July 1969.

National Aeronautics and Space Administration

INDIA'S EARTH RESOURCES SATELLITE

By H. P. Mama

On February the Soviet Union launched India's second satellite – the Satellite for Earth Observation (SEO) – from Kapustin Yar by a two-stage Intercosmos rocket (based on the SS-5 Skean). Late last year a scientific team headed by Dr. Satish Dhawan, Chairman of the Indian Space Research Organisation, visited Moscow to finalise the launch preparations. The success of SEO marks an important landmark and one that is being watched with interest by the world scientific community. The launch follows the success of Aryabhata, the first Indian satellite, launched on 19 April 1975 by the USSR, dedicated to research into X-rays from stars, neutron and gamma radiations from solar flares, and particles and radiation fluxes in the Earth's ionosphere. K.W.G.



India's Satellite for Earth Observation (SEO) being dynamically balanced.

Indian Space Research Organisation (ISRO)

Satellite Design

Utilising the unused back-up Aryabhata bus, SEO is a 26 faceted quasi-spherical polyhedron of 1.19 m height, 1.55 m equivalent diameter, and 6.5 m^2 surface area. The design helps obtain near-optimum incidence of solar radiation through the 26 body-mounted solar panels.

The design ensures that the moment of inertia about the spin axis is greater than that about the lateral axis, thus avoiding wobble. SEO is more prone to this problem because of its low (6 to 10 rpm) rotational rate, to facilitate the use of the observational payload, than the earlier Aryabhata (90 rpm maximum). For that reason, and to minimise height, a simpler cylindrical structure was avoided. For SEO, accurate spin rate is extremely vital to get the right overlaps of pictures to form a mosaic, which requires a very complex command system.

The HAL-made bus, of aluminium alloy, is in three parts – a top shell to cover the framework, a bottom shell holding the Soviet-made titanium pressure bottles of nitrogen, and the central deck plate holding the payload and equipment.

The top shell is of sheet metal and has angular sections welded by spot and argon arc welding. The bottom shell incorporates complicated machined fittings which are rivetted and welded. All structures are of imported 6061, 2022 and AMP6 aluminium or magnesium alloys. To exactly align the top and bottom shells, HAL had undertaken very accurate matching of components.

TV Cameras and Radiometers

Two slow-scan TV cameras and a passive microwave radiometer form the main payload of SEO. TV tubes for these special bands were specifically developed by Thomson-CSF, to ISRO specifications. The TV cameras operate in the visible (0.54 to 0.66 microns) and the near IR (0.75 to 0.85 microns) bands. While only two channels are available, they meet about 70% of the major requirements where low resolution is acceptable. Admittedly, a spin stabilised satellite is not the most suitable platform for such a payload as the cameras are able to work only when they look at Earth, but the system has the advantage of simplicity.

The two video bands are important for land-water assessment. Thus the 0.54 micron band shows up vegetation growth in cultivated lands, forests, marshy lands, etc. The 0.85 micron band is useful for studying such regions as thickly wooded river basins, mountain ranges (with or without vegetation), etc. SEO is particularly useful for study of resources that change with time and are renewable, like cultivated land, forests, rivers, snow and wetlands in coastal areas.

Each picture, taken from a 525 km near-circular 51° inclination orbit, covers an area of 341 km^2 and has resolution of 1 sq km. In view of the low resolution, only gross details will be available. The two bands help with computer classification. From black and white pictures, it is possible to generate false colour composites. Optimum results should be available through a co-ordination of digital processing and visual image interpretation.

The Space Applications Centre (SAC) of ISRO has developed a set of software designed for the IBM 360/44 PS available at the Physical Research Laboratory for digital remote sensing data handling. SAC's Photo Products Facility can generate pictures including colour composites, from digital data. Automatic photo processing equipment is available to produce black and white pictures for SEO data dissemination.

SEO's three-horn Dicke-type two-frequency Satellite Microwave Radiometer (SAMIR) payload is a passive receiver to measure microwave radiations in the 19.35 GHz and 22.235 GHz range, from the sea surface.

Fluctuations of microwave radiation will be detected in terms of brightness temperature with a resolution of around 1°K. Integrated brightness temperature data will be obtained over two adjacent circular areas of 125 km diameter each from the 19.35 GHz radiometers, and an overlapping area of 200 km diameter from the 22.235 GHz equipment. This type of instrumentation is not yet in widescale use. Both major payloads have posed significant challenges.

The radiometer has been designed primarily to study the ocean. The brightness temperature of the ocean is proportional to the product of emissivity and the physical temperature. Emissions from the sea surface at these frequencies are not directly proportional to the physical temperature but are a linear function of sea state, sea surface temperature, water vapour and liquid water content in the atmosphere. As emissivity varies with water conditions, it would thus be possible, by calculating the emissivity, to obtain sea surface temperature, ocean wind velocity, moisture content, sea state, etc.

Data Collection/Relay Package

ISRO has produced a Data Collection/Relay Package – a reliable unattended, battery-powered package that can be placed in remote areas to collect meteorological data such as wind speed, temperature, rainfall, pressure, sunshine, etc., and transmit these data to a central receiver station *via* the SEO satellite.

Eight such platforms will be deployed all over the country. Their signals at 401.5 MHz will be amplified and retransmitted by SEO at 136.43 MHz to the ground stations at Sriharikota and Ahmedabad. This is a forerunner of a very elaborate data collection system for the operational INSAT 1 satellite currently being fabricated by Ford Aerospace.

Apart from the main payloads produced by the Space Applications Centre, SEO also carries some secondary units (piggy-back). A passive X-ray payload in the form of a pinhole camera is mounted. It is designed to identify transient X-ray phenomena and was prepared jointly by the Tata Institute of Fundamental Research and ISRO. It has a position sensitive counter to give exact X-Y co-ordinates.

In another secondary experiment a prototype model of an ISRO-designed heat pipe is to be flown in SEO for qualifying it under prolonged space environment and micro-gravity conditions. This experiment is conducted in view of the potential use of heat pipe devices for future missions.

Yet another technological experiment included in SEO is the thermal control cooling package. In this package, indigenously manufactured thermal paint samples (white and black) are flown to study the degradation effects of paints in the space environment. The paints were developed by Propellant Engineering Division (PED) of VSSC, and will help to maintain inside temperature in the 0° to 40°C range.

SEO's outer surface is covered by about 3,500 Soviet-supplied silicon N/P solar cells generating a total of about 40 watts average power. Included in these is a small panel of Indian-made cells for space qualification tests. A 10 AH Ni-Cd battery is provided to store power. ISRO is developing solar cells within India along with the Bhabha Atomic Research Centre and Solid State Physics Laboratory. These should be available in about two years.

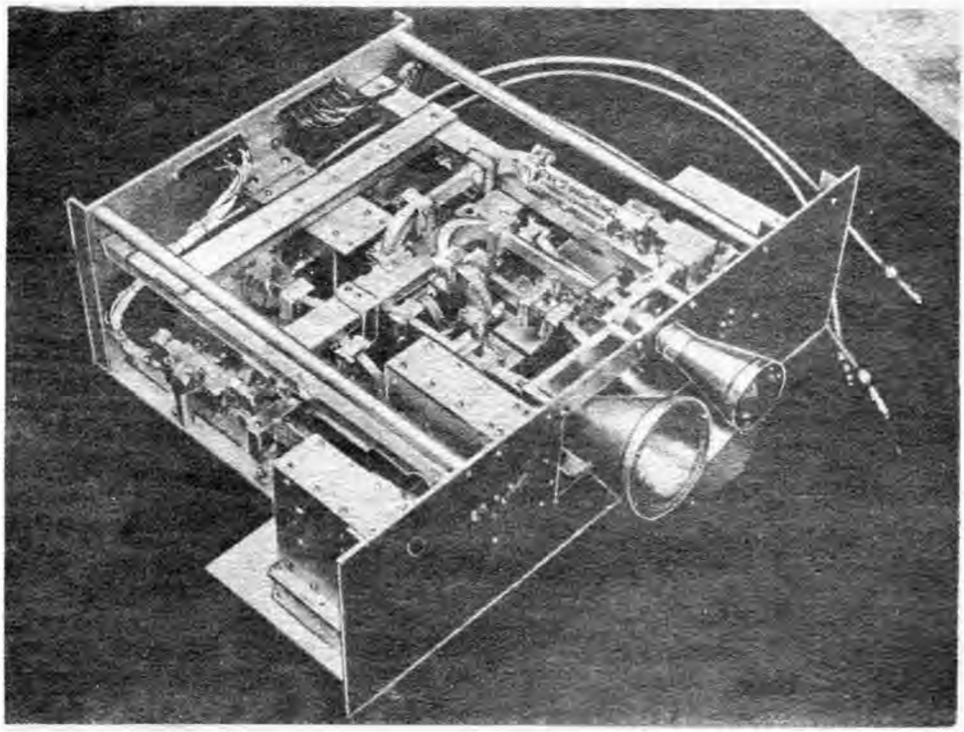
Among the usual on-board equipment are telemetry, telecommand and communications systems as well as the Earth, Sun and horizon sensors. Apart from Aryabhata's cold gas jet spin system, SEO also has two cold gas thrusters firing along the spin axis in a 'bang-bang' mode for attitude corrections.

In overall charge of the project is the ISRO Satellite Centre (ISAC), Bangalore. ISAC did all the testing, integration and final preparation of the satellite. Mission control is located at Sriharikota; signals are also being received at Ahmedabad.

Future Plans

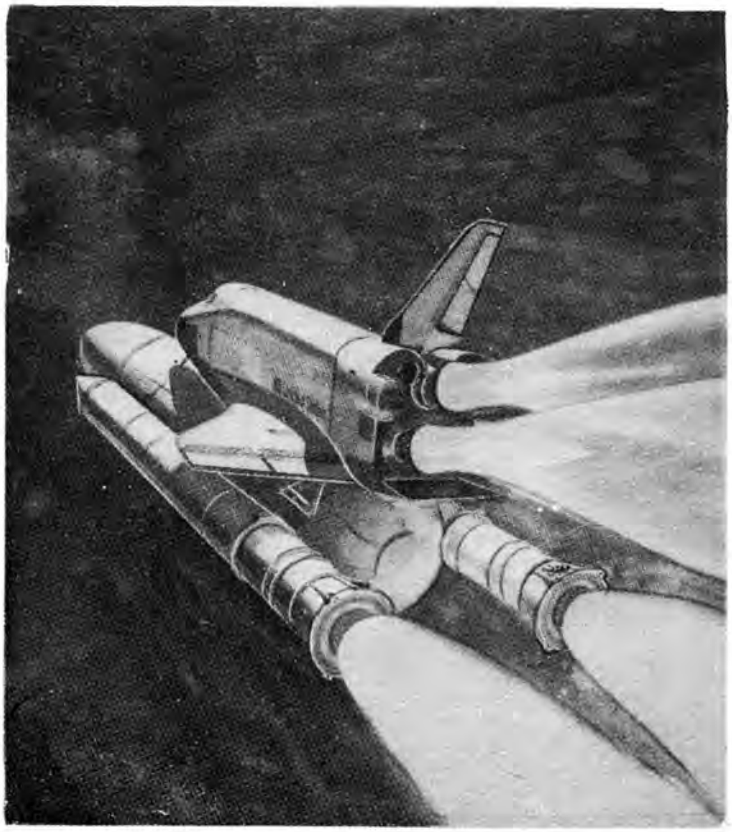
For the future, ISRO is working on the operational Indian Remote Sensing Satellite (IRS). It will be applicable mainly to agriculture, soil studies, hydrology, forestry, coastal oceanography and geology. Discussions are already under way with the potential users so as to optimise the payloads to India's specific requirements. While no details are yet available, it is likely to have a multispectral scanner, possibly based on the five-channel unit currently used for aerial surveys.

While India has found Landsat data to be extremely useful, and the National Remote Sensing Agency is setting up a 10 m diameter ground station at Hyderabad for receiving remotely sensed data, only a fully Indian-designed satellite can adequately meet India's wide ranging requirements.



The Satellite Microwave Radiometer (SAMIR) for SEO, manufactured at the Space Applications Centre, Ahmedabad.

Indian Space Research Organisation



FIRST FLIGHT OF 'COLUMBIA'

The 3,000 mile trip from NASA's Dryden Flight Research Center in California to the Kennedy Space Center began with a 38-mile overland move from the Rockwell International plant at Palmdale to Dryden, writes Gerald L. Borrowman. However the first snag to plague the journey came when Columbia was being hoisted on top of the 747 by a Mate-Demate device. The mating of the two vehicles was delayed nine hours. The two vehicles were misaligned because Columbia was not built to the exact specifications of its predecessor. Special tools and the cutting of a metal plate around one of the struts attached to the top of the aircraft was required before Columbia could be bolted to the 747.

Then on the afternoon of 9 March during the first test flight of the Orbiter-747 combination from the seven-mile runway at Edwards Air Force Base another problem arose. The flight was to ensure that all systems were ready for the flight to the KSC on the following day. Fitz Fulton the pilot of the 747 notified ground-control that the Orbiter was shedding its dummy thermal protection tiles and that ground support personnel should remove the pieces of tile from the runway before he would attempt a landing.

While the problem was being analyzed the two vehicles were removed from the outdoor Mate-Demate Device to a large hangar when adverse weather conditions developed. Weather played a role in deciding when the two vehicles would depart because of possible damage by the effects of rain on the permanent thermal protection tiles.

Finally on 20 March at 4:12 p.m. EST Columbia and its 747 mother ship left Edwards Air Force Base to land at 6:55 p.m. at Biggs Army Air Field at El Paso, Texas. The Orbiter and her transport were supposed to fly to San Antonio, Texas, but bad weather forced the 747 crew to divert to El Paso. During the two-and-a-half hour flight only one of the dummy thermal protection tiles affixed to the Orbiter had been damaged.

Weather problems kept the Columbia Earth bound in El Paso until 2 p.m., 23 March when it departed for Eglin Air Force Base, where it arrived at 4:15 p.m. Then on 24 March at 9:30 p.m. the last leg of the flight began.

Riding piggyback on its 747 transporter America's first real spaceship touched down at the Kennedy Space Center at 11:03 a.m. After a two week delay caused by bad weather and replacement of dummy tiles the combination of vehicles made three passes – the approach, the low pass over the runway and the landing. After the landing the two vehicles were towed behind a speakers platform and served as a background for the dignitaries including NASA chief Robert Frosch, Astronauts John Young and Bob Crippen, and the director of the KSC Lee R. Scherer. Dr. Frosch cautioned that "hard work – lot's of hard work"– lay ahead for the engineers and technicians assigned to the Shuttle programme at the space centre. The director of the KSC said he was sure that the Kennedy technicians would "be delighted to get their hands on the real hardware."

Overhead Deke Slayton, NASA's manager of Orbiter flight tests, flew his T-38 jet over the Shuttle runway and screamed into an almost vertical climb and then went into a series of rollovers.

At 8:30 a.m. EST the next morning Columbia was towed two miles from the runway to the Orbiter Processing Facility to begin the long process of preparing the craft for its first launch. The first task was to remove and replace more than 3,000 dummy protective tiles that were placed on the Orbiter to give it and its 747 carrier aerodynamic stability.

The installation of the tiles had been a major factor in delaying the arrival of Columbia at the KSC. The dummy tiles were originally attached by two methods – either by special glue or two-sided tape. During a test flight the dummy tiles attached to the side of the Orbiter fell off. NASA officials then decided to use special glue instead of tape to attach the new tiles to the spaceship.

To further compound the problem 100 of the permanent thermal protection tiles were damaged when special tape used to cover areas where no tiles were installed broke away from the Orbiter, and struck both the dummy and permanent tiles.

John F. Yardley, NASA Associate Administrator for Space Transportation Systems, said he wanted to see the results of testing that was done with a T-38 jet. That aircraft had dummy tiles attached to it to check out the new bonding techniques. The cause of the problem was greater turbulence than anticipated as the placement of dummy tiles attached by glue and the tape at speeds higher than those of the 747 had been satisfactory.

With the Columbia now safely tucked away within the confines of the Orbiter Processing Facility it was fed electrical power for the first time on Friday, 30 March. This was the first time the launch processing system had been interfaced with the Columbia. At about the same time a 154-foot-long external tank was towed into the Vehicle Assembly Building. The tank will be used as a pathfinder for the Shuttle programme and later as a piece of actual flight hardware. The tank had been brought to the KSC by the NASA barge Poisedon on Wednesday, 28 March from the Michoud Assembly Facility in Louisiana.

The tank will be part of a "pathfinder" programme in which the Enterprise will be placed on top of a mobile launch platform and mated to an external tank which in turn will be connected to two solid rocket boosters. This combination will then be moved on a crawler transporter from the Vehicle Assembly Building to Launch Complex 39A. It will remain there for several months while technicians check the compatibility of the space transportation system to ground support equipment.

T 8

BRITAIN PROBES THE HIGH-ENERGY UNIVERSE

Introduction

Britain's latest scientific satellite Ariel 6 carries three experiments which could greatly extend our knowledge of the high-energy universe. As we closed for Press, the 150 kg satellite was being prepared for launching by a NASA Scout rocket from Wallops Island, Virginia, on 24 May. It was expected to enter a circular orbit of some 600 km inclined at 55 degrees to the equator; period 96 minutes.

Ariel 6 was built by Marconi Space and Defence Systems at their space laboratories in Portsmouth under a £4 million contract from the Science Research Council. British Aerospace, Filton Division, designed and manufactured the satellite structure and mechanism including the body (based on the Ariel 4 design), the four deployable boom assemblies, the solar array honeycomb panels and the outer aluminium shell for the cosmic ray detector. Spectrolab (USA) supplied the solar array panels, including attachment of solar cells to the honeycomb panels and cell interconnections.

Scientific Background

High energy astrophysics is concerned with the study of astronomical phenomena involving large energy densities and highly energetic sources. The best examples of such sources are quasars, radio galaxies, supernovae and pulsars. They emit electromagnetic radiation copiously over almost the entire band of wavelengths, and we can deduce from our knowledge of their radio emissions that they also emit high-energy particles.

With the development of X-ray astronomy many new and exciting features of these objects have been revealed. In this field the Ariel 5 satellite was a leading contributor. Ariel 6 studies will extend the wavelength range to be studied into the soft X-ray region.

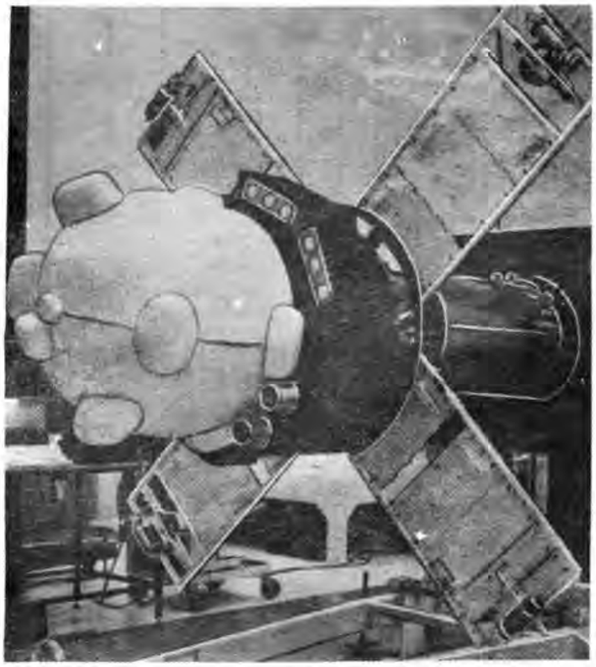
The prime experiment, the Bristol cosmic ray detector, should provide the first satellite data on the charge spectrum of heavy cosmic ray primary particles. Cosmic rays remain the only samples of matter from outside the Solar System, and the distribution of elements will give a valuable insight into the conditions at the source of cosmic ray generation.

The Experiments

The cosmic ray experiment, by the University of Bristol (Professor P. H. Fowler FRS), has been designed to study the ultra-heavy component of cosmic radiation, using a spherical gas scintillation/Cerenkov detector mounted on top of the spacecraft's main structure. The interior volume of the sphere will be viewed by an array of photo-multiplier tubes, and a comparison of the gas scintillation and Cerenkov pulses produced by a cosmic ray particle will enable the charge of the particle to be determined.

Of the two X-ray astronomy experiments, the instrument provided jointly by University College London's Mullard Space Science Laboratory (Professor R. L. F. Boyd) and the University of Birmingham (Professor A. P. Willmore) will carry out observations at photon energies below 2 keV with an array of four grazing incidence X-ray reflectors and thin window proportional counters mounted in two pairs and viewing in the forward direction along the spacecraft spin axis.

The University of Leicester (Professor K. A. Pounds) provided an instrument to study variable X-ray sources with high time resolution in the energy range 1 to 50 keV by means of four gas-filled thin window proportional counters. The 3° field of view will be determined by a collimator assembly and the viewing axis will be aligned to the spacecraft spin axis.



UK-6 scientific satellite.

Marconi Space and Defence Systems

In addition there are two technology experiments from the Royal Aircraft Establishment involving CMOS and solar array elements.

Spacecraft Design

The main body of the satellite is approximately cylindrical, with a spherical detector for the cosmic ray experiment mounted at one end. The two X-ray experiments are mounted on the sides of the spacecraft viewing parallel to the spin axis and past the sphere.

An array of solar cells is carried on four deployable booms which in orbit will be at 90° to the spacecraft spin axis, mounted at the opposite end to the spherical detector. When the satellite is in the Earth's shadow, power will be provided by twelve 6Ah nickel-cadmium cells.

The data handling system includes a dual four-track tape recorder unit for storing data while the spacecraft is out of contact with a ground station. Telemetry data acquisition and command operations will normally be conducted from the NASA Spaceflight Tracking and Data Network (STDN) station at Winkfield (which is operated by the Appleton Laboratory) with overall control of orbital operations being directed from the Control Centre at the Appleton Laboratory.

The Role of Marconi

Marconi Space and Defence Systems had design authority responsibility for the following aspects: • mechanical, thermal and electrical design of the spacecraft system; • spacecraft configuration; • system interfaces; • configuration and control; • common service electronic equipment including power and signal distribution wiring; • solar array battery and power conditioning equipment; • v.h.f. communications equipment; • telecommand data decoding and processing equipment; • telemetry data encoding; • processing and storage equipment; • attitude sensor data processing electronics and • attitude control equipment.

SPACE REPORT

A regular monthly review of Space Events and Technical Trends

SPACE CONSTRUCTION TOOLS

Spacecraft design engineers at the Johnson Space Center have tested a conceptual "cherry picker" attachment for use with the Shuttle Orbiter remote manipulator arm.

This "proof-of-concept" test is the first step in the research and development of a set of space construction devices which, is approved and developed, would enable Space Shuttle astronauts to carry our near term (1980's) satellite servicing, maintenance and repair and far term (1990's) large construction projects in Earth orbit.

The test involved the use of a prototype Space Shuttle suit which physician-astronaut Joe Kerwin wore while following a series of procedures in the Space Center's water immersion facility, working the "cherry picker" in the neutral bouyancy of the water.

The conceptual "cherry picker" has controls at the work station so the astronaut can control the motions of the remote manipulator system (RMS). Normally the RMS would be operated by the mission specialist from inside the Orbiter.

The envisioned use of this device would be to service on-orbit satellites which are attached to the Orbiter without an astronaut floating freely in space.

The manned remote work station concept was designed after a series of studies by Space Center engineers and outside contractors. The test model was manufactured by the Grumman Aerospace Corporation, Bethpage, New York. Following the test, the concept model was returned to Bethpage, when Space Center and Grumman engineers discussed any needed modifications.

These early tests will provide the basis for the manufacture of a development test article which is expected to be delivered to the Space Center early in 1980. This is expected to be tested on an air-bearing floor with the "cherry picker" attached to the end of an engineering development RMS using either engineer test subjects or astronaut test subjects wearing the Shuttle suit. The tests results are expected to be used as the basis for the development of a flight test article which then would be tested in space on one of the Space Shuttle Orbiter flights.

The "cherry picker" concept is envisioned as the "Model T" of a series of space construction work platforms – some of which are completely enclosed and pressurised; some like the "cherry picker" are open and require a suited crewman. Others would be miniature space vehicles capable of carrying cargo or personnel from the Orbiter to other points in space.

At present all these concepts are in the study and preliminary design stage; the space agency has not received funding for the development of any of this equipment. If developed, though, all construction support equipment would be for various types of construction envisioned in both low and high Earth orbits (from 100 to 600 nautical miles) and would have to be reusable and compatible with the Orbiter payload bay.

In addition to the studies at the Johnson Space Center, the Marshall Space Flight Center also studies concepts for space construction projects.

FILTERING EARTH RESOURCES DATA

An optical device being developed at Battelle's Columbus Laboratories may help NASA simplify processing of Earth resources data being monitored by satellites. Called an integrated optical data preprocessor, the device is being designed for installation in satellites to identify and then sort useful data from redundant data before relay to Earth receiving stations. Researchers have developed a three-channel laboratory version and are currently designing a 16-channel model. The work is being sponsored by NASA's Langley Research Centre.

According to Battelle's Dr. Carl M. Verber, current sensing devices are constantly collecting much data that are uninteresting or redundant. For example, when the objective of a monitoring satellite is to record concentrations of pollutants in the ocean, most of the data sent back depict vast amounts of clear water.

In such an instance, the Battelle device would discriminate between water that is clear and water that has impurities. This would reduce data transmission, storage, and processing loads as well as computational problems.

Dr. Verber says the preprocessor would simultaneously analyze data obtained from a number of sensor channels rather than sequentially processing the information from the sensors. This process would permit faster analysis and reduce equipment needs.

As designed by Battelle, the device is essentially a holographic recording device on a crystal of lithium niobate. A hologram representing a desired set of data is written into the crystal, Dr. Verber explains. This programmed data-set serves as a reference to quickly compare against all new incoming sets obtained from the spectral characteristics of the light reflected from various portions of the Earth's surface. The incoming information is rejected if it is not relevant.

In the ocean example, for instance, the referenced pattern in the hologram would represent clear water. If similar data are subsequently received, the detector would identify them and reject them before relay transmission occurs.

The system consists of a laser, optical beam splitters, a mirror, an electro-optic phase shifter, data input electrodes, and the hologram region.

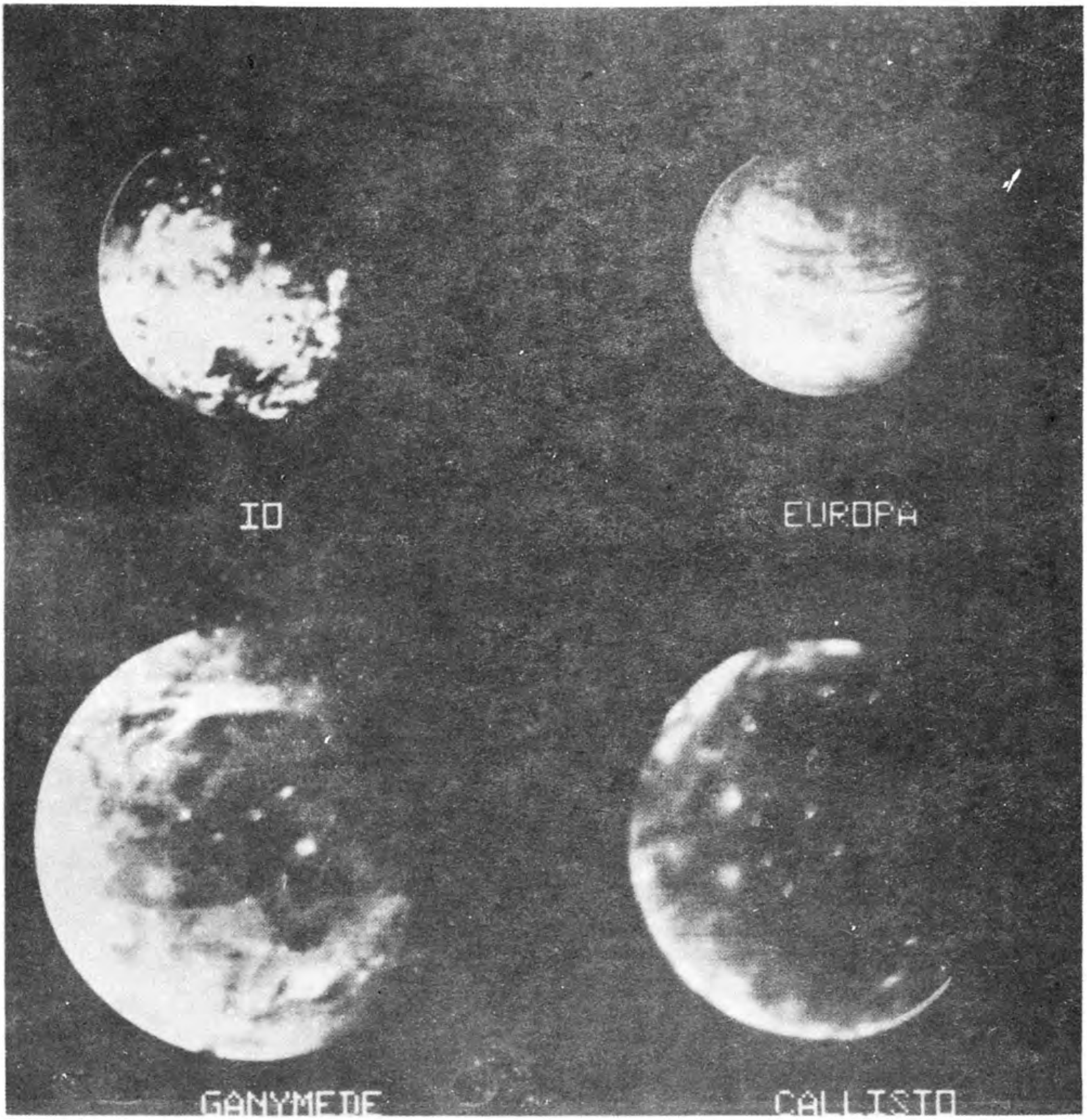
The three-channel device Battelle developed during the past two years has demonstrated the concept is workable, Dr. Verber said. Only one by one-half inch in size, the device has been shown in the laboratory to display ample sensitivity for screening applications.

ANTARCTIC METEORITES

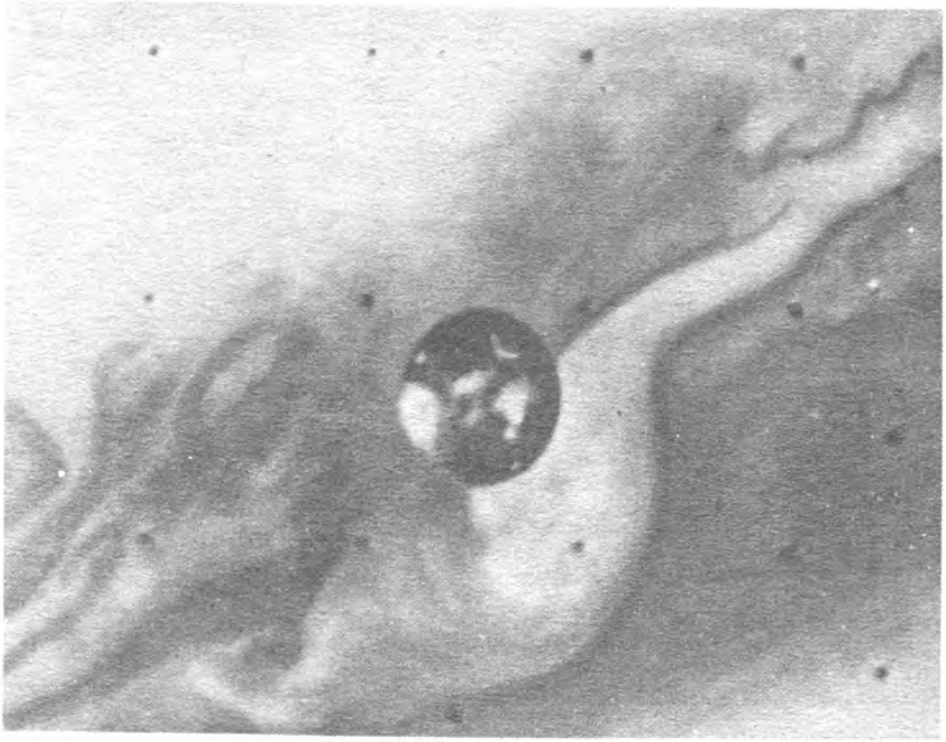
The third scientific expedition to look for frozen meteorites on the Antarctic ice shelf has been completed successfully. The three-month expedition, headed by University of Pittsburgh professor Dr. William Cassidy and consisting of teams of American and Japanese meteorite searchers, found 309 meteorite fragments during November, December and January, the southern summer months.

The expedition was supported with equipment and lunar-style storage and retrieval material from NASA's Johnson Space Center. JSC associate lunar curator John Annexstad, who took part in the expedition, says the samples collected this time were even more carefully collected than the samples retrieved during last year's, second, expedition, the first to use lunar-style collection techniques.

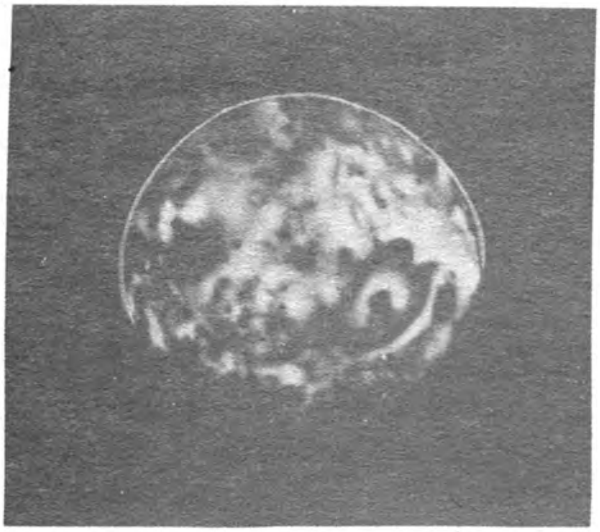
The samples are being curated and prepared for scientific examination at the JSC lunar and planetary science division laboratories. The Antarctic meteorites are of greater scientific value than most meteorites because of the preserving qualities of the extreme cold and arid conditions on the ice shelf.

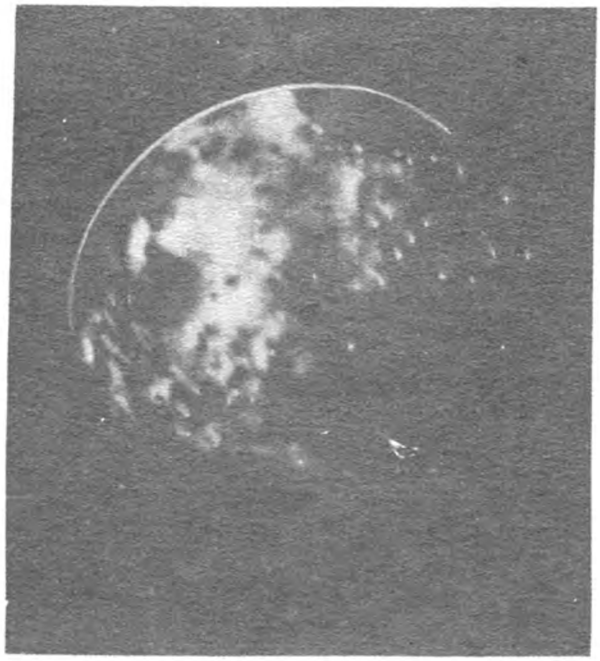


GALILEAN MOONS. The four large moons of Jupiter photographed by Voyager 1 with violet filters between 1 and 3 March. North of each photo as at the bottom. On this picture they are shown at their correct relative sizes. The two biggest, Ganymede and Callisto, are larger than the planet Mercury, while Io and Europa are roughly the size of Earth's Moon. Picture processing preserves relative contrasts on the satellites; thus it is apparent that Europa has the least contrast and Io the greatest. The two brightest, Io and Europa, have surfaces of very different compositions. Io is thought to be covered with sulphur and salts, and Europa with water ice. Ganymede has both ice and rock exposed on its surface, while Callisto is primarily rocky. These surface properties contrast sharply with the interiors of the satellites: Io and Europa have rocky interiors, while Ganymede and Callisto contain large quantities of water and ice. The smallest markings on these images are about 50 km across except for Callisto which has a resolution of 96 km.

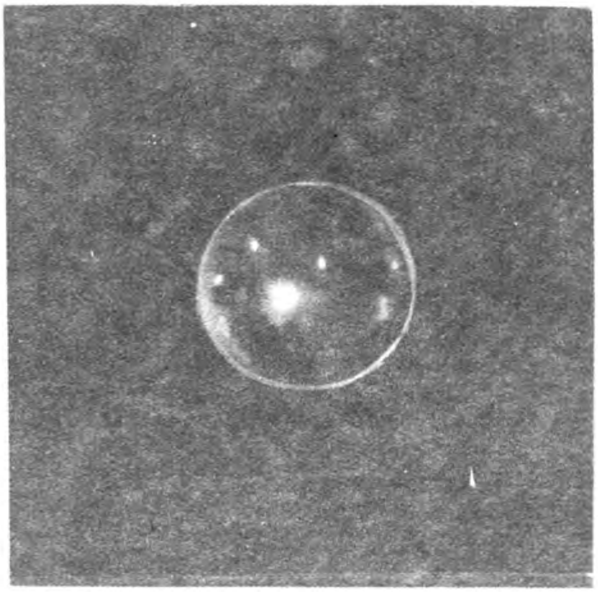


This photo of Io was taken through an ultraviolet filter by the narrow-angle camera of Voyager 1 from a distance of 7 million kilometres on 27 February, and is seen against a background of Jupiter. North is at the top, and the central longitude of Io is 180 degrees. This intriguing body, almost exactly the same size and density as our own Moon, has followed a very different evolutionary history, influenced by its proximity to Jupiter and the intense bombardment it receives from the Jovian radiation belts of energetic charged particles.

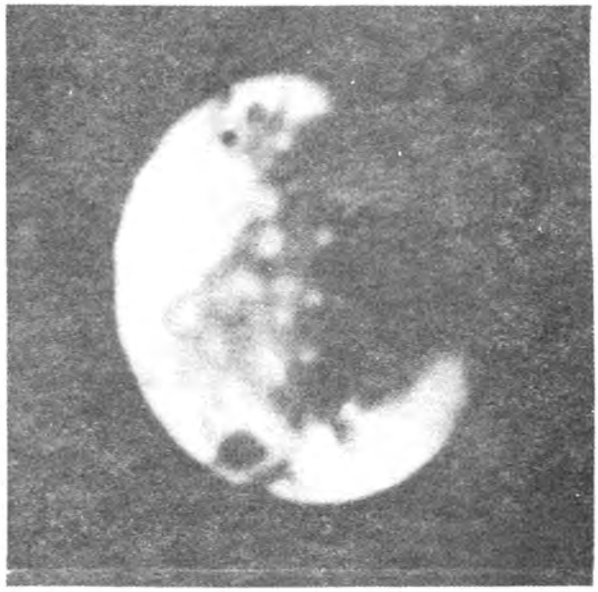




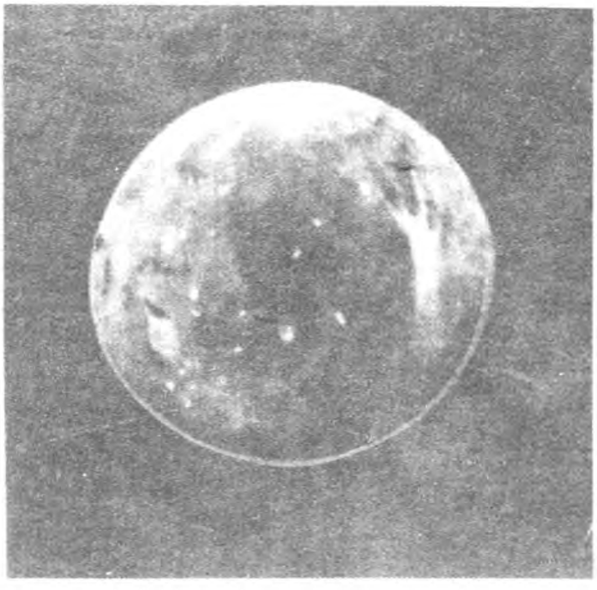
Io–Jupiter's innermost Galilian satellite–photographed on 2 March from a distance of 2.9 million kilometres. Smallest details visible are about 60 km across. The region shows some remarkable features, the most prominent being the large spot in the southern region. This spot, about 900 km across, has a dark centre surrounded by a brighter halo, and then a darker ring. The trailing face of Io is shown in this photo taken on 3 March from a distance of 2.7 million kilometres. A bright yellow-orange equatorial band separates the darker reddish-brown polar zones. Characteristic of Io's surface is the profusion of dark spots commonly surrounded by rings of brighter material. The smallest dark spot visible in this view is 30 kilometres wide; the largest is about 400 km across. Subsequent high-resolution coverage revealed that the dark spots were volcanoes. The reddish colour of Io has been attributed to sulphur in the salts. Water frost, which occurs on the surface of other Galilean satellites, is absent on Io.



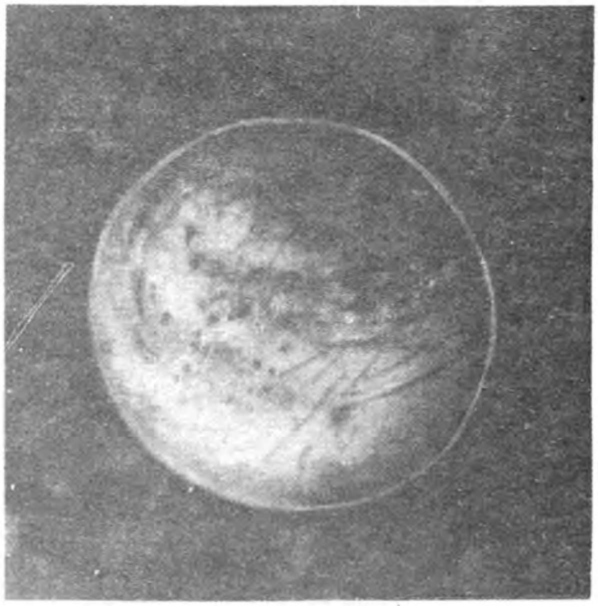
Voyager 1 took this picture of Ganymede from a distance of 8 million kilometres on 26 February. Ganymede is the largest of Jupiter's 13 known satellites. Slightly larger than the planet Mercury, it has a density about twice that of water. That leads scientists to believe it is composed of a mixture of rock and ice. The bright spot near the centre is five times brighter than the Moon, and may contain more ice than the surrounding areas. First thoughts were that it may be an impact crater that had exposed fresh, underlying ice.



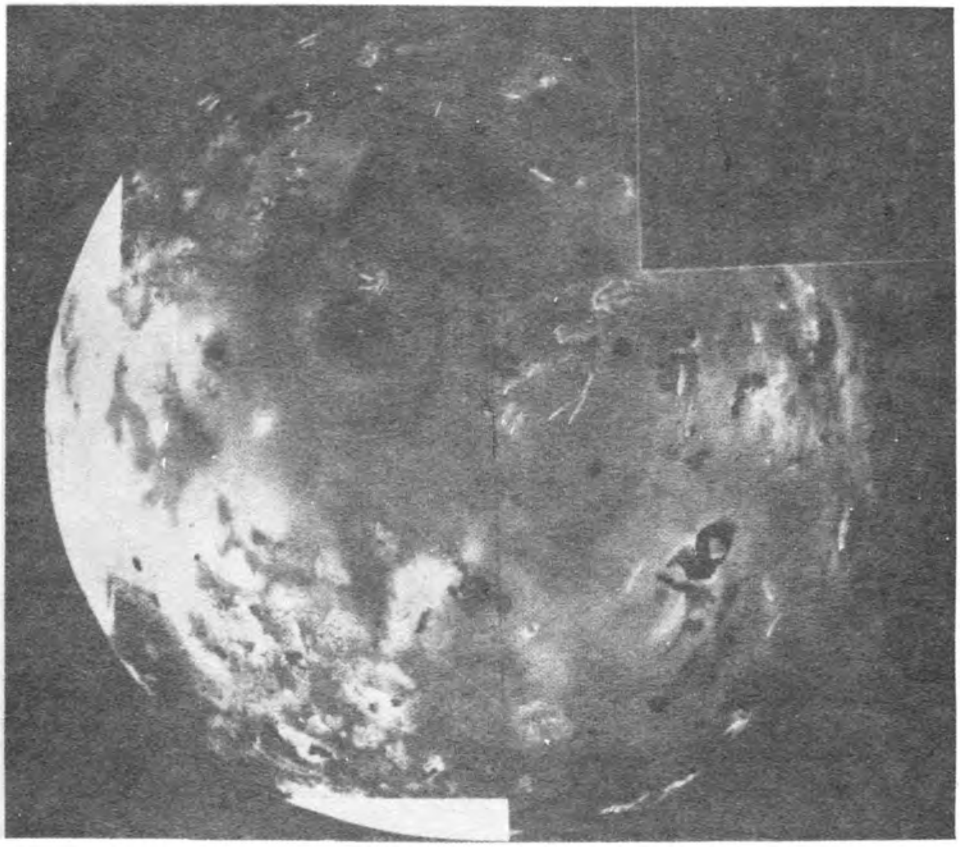
This photograph of Ganymede was taken on 27 February when the spacecraft was about 6 million kilometres away. North is up and the central longitude is about 120 degrees west. The picture shows dark markings which look like the dark mare regions on our Moon, but on Ganymede they are twice as bright as lunar mare and are unlikely to be composed of rock or lavas. The north polar region appears to be covered with brighter material, probably water frost. JPL scientists said if later pictures of this polar area show blanketing of underlying terrain, it could indicate movement of water on Ganymede's surface, possibly in a very thin atmosphere. Brighter spots are scattered over this hemisphere of Ganymede. These may be related to impact craters or may represent source areas of fresh ice.



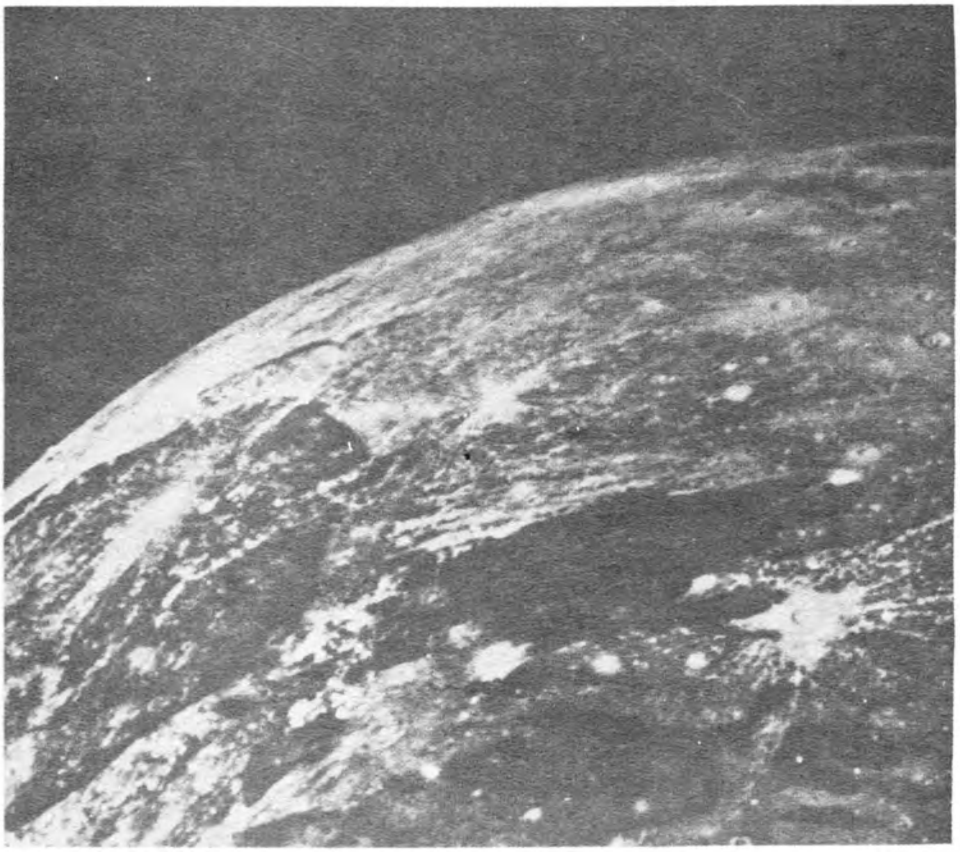
This photograph of Ganymede, Jupiter's largest moon, was assembled from three black and white pictures taken on 2 March from a distance of about 3.4 million kilometres. This face of Ganymede is centred on the 260 degree meridian. At this resolution the surface shows light and dark markings interspersed with bright spots. The large darkish area near the centre of the disc is crossed by irregular light streaks somewhat similar to rays seen on the Moon. The bright patch in the southern hemisphere is reminiscent of some of the large rayed lunar craters caused by meteorite impacts.



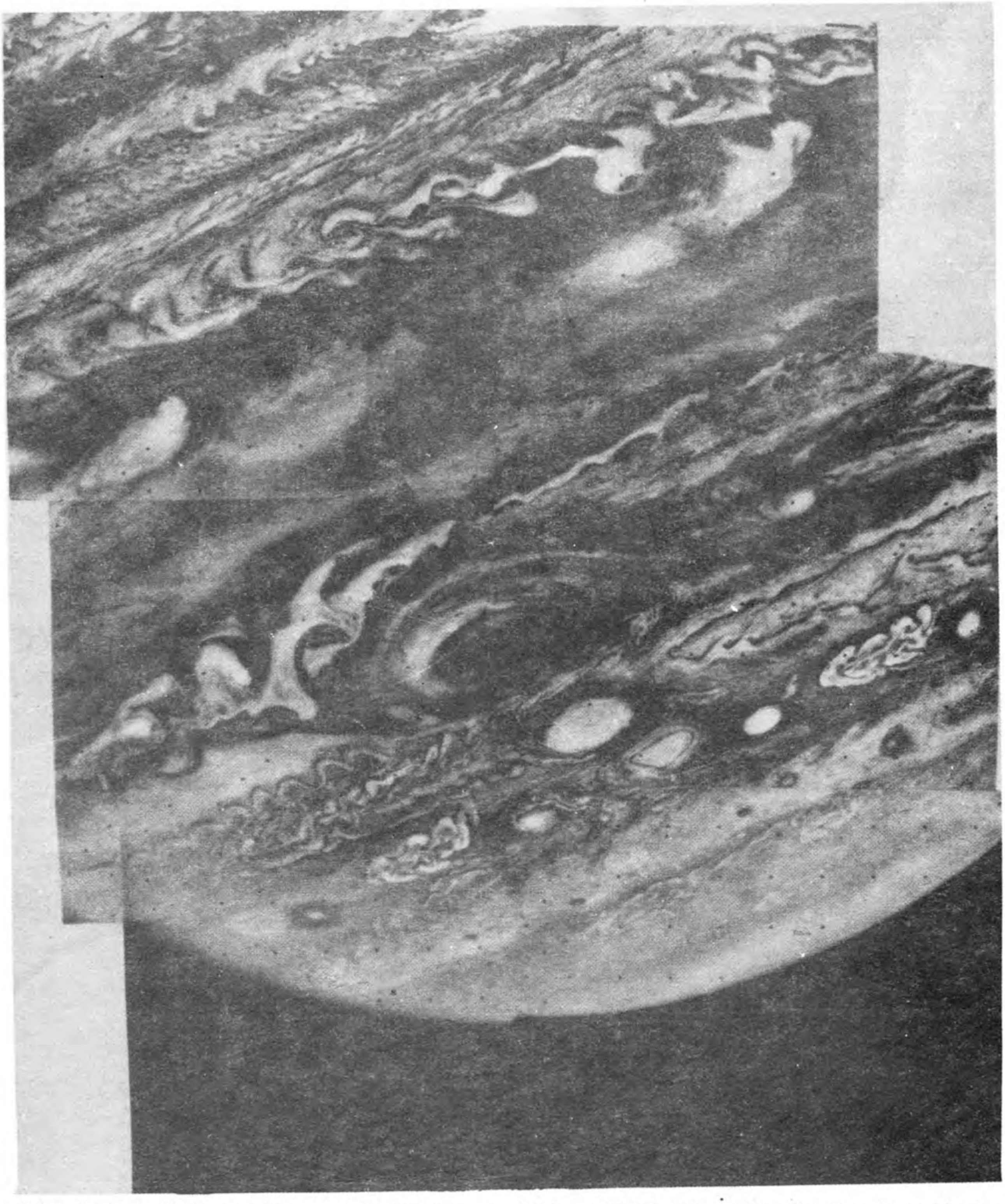
Europa photographed on 2 March from a distance of 2,869,252 kilometres. Irregular dark and bright patches on the surface are different from the patterns on the other moons of Jupiter and those on the Moon, Mars and Mercury. Dark intersecting lines may be faults that break the crust. This is the face away from Jupiter.



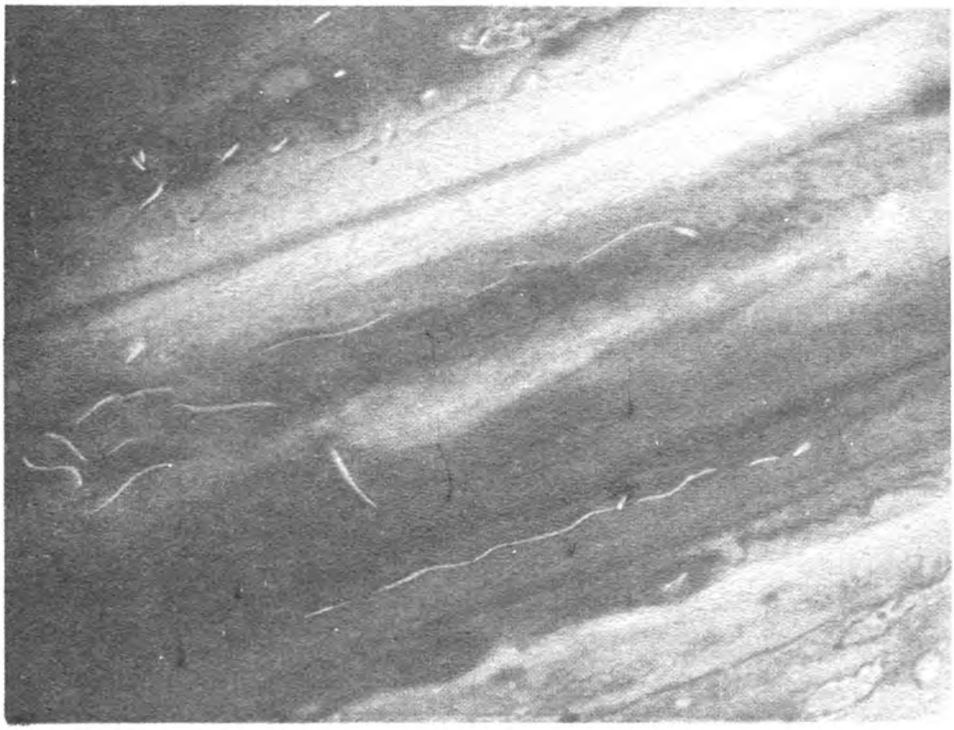
Io shows a volcanic surface to the camera in this four-picture mosaic obtained from a distance of 376,950 km on 4 March. The surface is believed to consist of mixtures of salts and sulphur brought to the surface by volcanic activity. This surface is thought to be the source of material for the clouds of neutral and ionised atoms in Io's spatial environment observed by Earth-based telescopes and also the doubly ionised sulphur torus discovered by Voyager 1's Ultraviolet Spectrometer experiment.



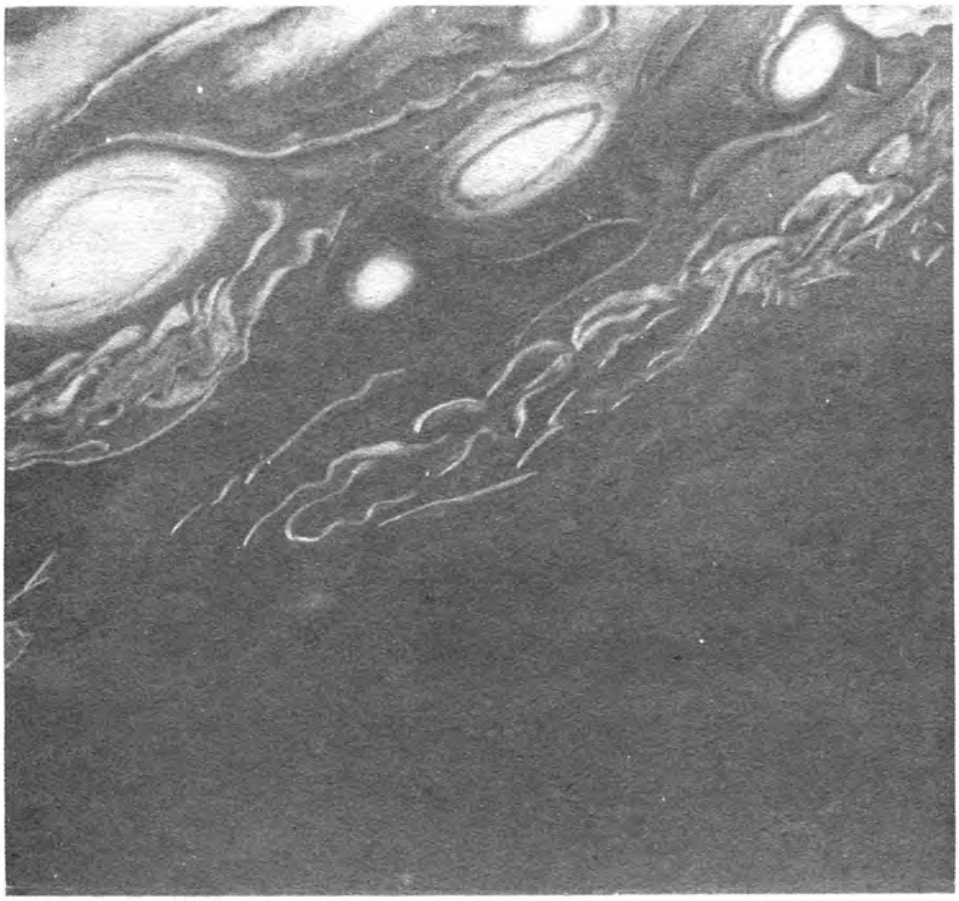
Many bright impact craters are seen in this picture of Ganymede taken by Voyager 1 on 5 March. Several have radial ejecta patterns that lie across the bright and dark background material. Many older impact craters are shown that have lost their rays probably by impact erosion. The bright background areas contain grooves and ridges that may be caused by faulting of the surface materials.



This mosaic was assembled from six violet images taken by Voyager 1 on 27 February 1979 at a distance of 6.5 million kilometres from Jupiter. The swirling vortex type motion, so apparent in the Great Red Spot (below the centre of the mosaic) can also be seen in several nearby white clouds. These bright clouds and Jupiter's Red Spot are rotating in a counter clockwise direction. The peculiar filimentary cloud (to the right of the Red Spot) is circulating in a clockwise direction. The turbulence associated with the equatorial jet and more northerly atmospheric current is seen at the top of the picture. The smallest clouds seen in this mosaic are only 120 km across.



The small, dark oval near the right edge of the North Tropical Zone—the broad, bright band in the upper part of the photograph—may offer a glimpse deep into Jupiter's atmosphere; more study will be required to make certain. Between the regularly-spaced dark ovals near the bottom of the frame are more small-scale features that are being studied for their role in the Jovian atmospheric activity. The blue-grey regions along the sheer line between the Equatorial Zone and the North Equatorial Belt also appear to be windows into the deeper regions of the atmosphere. Earth-based observations tend to show these areas are warmer than surrounding regions.



This photograph taken on 1 March from a distance of 4.3 million kilometres looks toward the east from the Great Red Spot. The dark halo surrounding the smaller bright spot to right of the large oval is, scientists say, almost certainly a five-micron hot spot—a region of Jupiter's atmosphere that is warmer than those around it. That could mean that, in the dark halo, we are looking deep into Jupiter's atmosphere. The swirling streamer-like features may be associated with the bright spots, although the connection is not yet understood.

T 16 ASTRONOMICAL NOTEBOOK

By J. S. Griffith*

SOLAR SYSTEM

Winds On Venus

The upper atmospheric wind on Venus near the equator appears to have a retrograde motion of about -85 m s^{-1} with a periodically varying component with an amplitude of about 40 m s^{-1} and a period of 4.3 days.

Using the 1.5 m telescope on Mount Hopkins near Tucson, Arizona the authors of Ref. 1 alternately inspected the CO_2 line profile at the limb and at the terminator of Venus. Large daily variations in wind speed were observed with the underlying 85 m s^{-1} retrograde motion present. These results agree with those of Betz *et al* [2] and the generation of such retrograde winds is thought [3] to be due to a nonlinear instability involving both the mean meridional circulation and planetary-scale eddies.

[1] Traub, W. A. and Carleton, N. P., 'Retrograde winds on Venus: possible periodic variations,' *Astrophys. J.*, **227**, 329-333 (1979).

[2] Betz, A. L. *et al*, in *Proc. Symposium on Planetary Atmospheres* ed. A. Vallance Jones, (Ottawa, The Royal Society of Canada) (1977).

[3] Young, R. E. and Pollack, J. B., *J. Atm. Sci.*, **34**, 1315 (1977).

The Kirkwood Gaps

The Kirkwood gaps in the orbits of the asteroids are suggested to be primordial in nature, where resonance inhibited accretion.

The Kirkwood gaps must be due to resonance either removing asteroids or destructing them. In Ref. 1 it is argued that collisional mechanisms were available at an early accretion stage, preventing asteroids forming in the gaps in the first place. The model chosen is that of planetesimals orbiting a primary in the presence of a perturbing third body and of a nebula surrounding the primary. Then the discussion focuses on whether the planetesimals will grow by accretion or fragment in collisions. For the proposed mechanism to work it is necessary that the asteroids must have formed at the same time as Jupiter. However we are still not clear about the origin of the high values of the semi-major axes and eccentricities of the asteroids.

[1] Heppenheimer, T. A., 'On the origin of the Kirkwood gaps and of satellite-satellite resonances,' *Astron. & Astrophys. J.*, **70**, 457-465 (1978).

STARS

Alpha and Proxima Centauri

Analysis of all available observations of Alpha and Proxima up to 1971 gave new results for trigonometrical parallaxes and proper motions. A new mass ratio was derived, and observations are consistent with a common space motion for the two stars. The orbital motion of Proxima around Alpha is not neglible yet is not measurable at present. No perturbations due to low mass companions were found. The new masses for Alpha Centauri A and B are respectively 1.10 and 0.91 solar masses.

As the Sun's nearest neighbouring stars, the three members of the Centauri system have been objects of particular interest. In Ref. 1 a new analysis of the astrometric parameters of the system is undertaken. The separation between Alpha (with three components) and Proxima is about 13,000 AU, with Proxima's mass around 0.12 solar masses. The three components of Alpha have properties summarised below.

Component	A	B	C
Mass in terms of solar masses	1.1	0.9	..
Spectral type	4.3	5.5	11.7
Spectral type	B2V	K0V	M5e

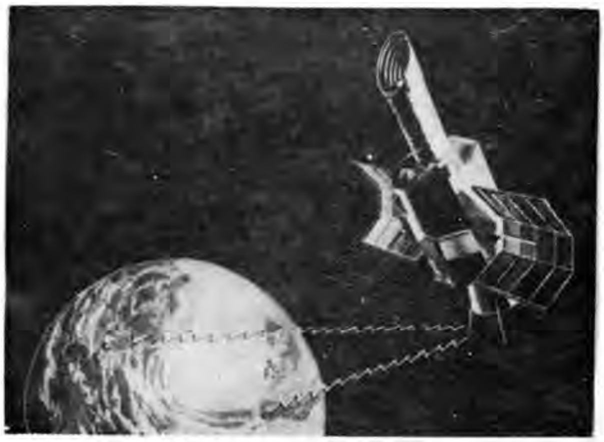
α Cen A is slightly more massive, brighter and more metal rich than the Sun.

[1] Kamper, K. W. and Wesselink, A. J., 'Alpha and Proxima Centauri,' *Astron. J.*, **83**, 1653-1659 (1978).

Discovery by the International Ultraviolet Explorer

The bright star HR 8752 has been discovered to have a hot companion by analysis of low resolution observations with the International Ultraviolet Explorer (IUE).

One of the most luminous stars in our Galaxy is HR 98752. Its present spectral type is G5 0-Ia and when observers were looking at the TV screen of the Experiment Display System of the IUE they were surprised to discover instead the spectrum of an early type star. There were many strong inter-and/or circumstellar absorption lines [1]. This hot companion to the super-supergiant HR 8752 is perhaps the first object to be discovered by the IUE. It appears to be a B1V star and the components are probably closer than the shell, which has a radius of 1400 AU. The distance of both stars is 3.0 kpc. The shell consists of



Artist's impression of International Ultraviolet Explorer (IUE) as it transmits data from Clarke (geo-stationary) orbit. It can transmit and receive information either from NASA's Goddard Space Flight Center, Greenbelt, Maryland or to the ESA station near Madrid, Spain.

National Aeronautics and Space Administration.

* *Lakehead University, Thunder Bay, Ontario, Canada.*

excited but tenuous hot gas and the masses of the G and B stars appear to be 25 and 15 solar masses respectively.

[1] Stickland, D. J. and Harmer, D. L., 'The discovery of a hot companion to HR 8752,' *Astron. & Astrophys. J.*, **70**, L53-L56 (1978).

Infrared Sky Survey

Using a 20 in (50.8 cm) aperture wide-field telescope in conjunction with a very large format (146 mm) image intensifier with a red-extended, multialkali photocathode, a photographic survey of the Northern sky is currently being made. Among the advantages of the method are the cataloguing of red stellar objects and the examination of regions of the sky which are obscured by hydrogen emission on normal photographs.

The equipment used for the survey at Steward Observatory, Arizona, is described in Ref. 1. For many of the objects photographed (for example the Orion nebula) this survey presents the first photographs not contaminated by hydrogen emission and interesting information on the distribution of reflecting material in nebulae becomes available. The removal of hydrogen emission enables a study to be made of the underlying stellar content of such regions as M16, where the infrared image reveals many stars in the region of visible obscuration.

[1] Craine, E. R., 'Optical Infrared Sky Survey,' *Astron. J.*, **83**, 1598-1606 (1978).

NEBULAE

Interstellar Ice

Interstellar ice extinction in the ρOph dark cloud gives rise to an absorption band that indicates that growth of ice mantles is not responsible. Ice mantles only form in the densest regions in clouds and do not give rise to any significant change in the infrared broad-band extinction law.

The authors of Ref. 1 used the 1.5 m and 2.3 m telescope at the University of Arizona to obtain conventional infrared measurements. They found that the polarization characteristics in the cloud are not due to the coating of grains with water ice, but probably arise from silicate-metal oxide coating of the grains. Even where ice band extinction is seen, its strength probably corresponds only to a small fraction of the total amount of ice available.

[1] Harris, D. H., Woolf, N. J. and Rieke, G. H., 'Ice mantles and abnormal extinction in the rho Opiuchi cloud,' *Astrophys. J.*, **226**, 829-838 (1978).

GALAXIES AND QUASARS

Galaxies and Quasars

Two galaxies close to the quasar III Zw 2 have redshifts that confirm their common cluster membership with the quasar, which must therefore be at cosmological distance.

The object III Zw 2 was originally considered to be a compact galaxy. Later observations [1] revealed it to be a quasar. Using the multichannel spectrophotometer on the Hale 5 m telescope the authors of Ref. 1 examined two galaxies within 3' of III Zw 2. The three objects and their surrounding nebulosity all have redshifts of the order of $z = 0.09$, thereby establishing the cosmological nature of the emission-line redshift of the quasar. The nebulosity to the northwest of the quasar exhibits a spectrum consistent with that of starlight at the system redshift.

[1] Green, R. F., Williams, T. B. and Morton, D. C., 'Spectrophotometry of the galaxies and nebulosity associated with the quasar III Zw 2,' *Astrophys. J.*, **226**, 729-735 (1978).

Quasars, radio galaxies and gamma-ray sources

The proposition is put forward that the nucleus quasars and radio galaxies contains a powerful high-energy gamma-ray source. The emitted gamma rays interact with photons to produce electron pairs, transporting energy from the nucleus to both the compact and extended radio components.

In Ref. 1 it is pointed out that quasars and radio galaxies often have a central object and two diametrically elongated lobes emitting non-thermal radio energy. Hot spots are often to be found at the extremities of the lobes.

The concept presented is the emission of two blobs of gamma-rays from diametrically opposite sides of the central object. Only at energies above 10^{14} ev does dissipation of the gamma radiation occur. Then electron pairs are produced by photon-photon collisions on the micro-wave background. These electrons may dissipate by synchrotron emission and the formation of a relativistic shock-front.

It is also pointed out that the presence of a black hole at the centre may well be the origin of the gamma radiation, as black holes have already been suggested as viable candidates for galactic gamma-radiation.

[1] Swaneburg, B. N., 'Quasars, radio galaxies and gamma-ray sources; a sketch,' *Astron. & Astrophys. J.*, **70**, L71-L73 (1978).

A Correlated Radio-Optical Outburst from a Quasar

2.2 years after an optical outburst from the quasar 0420-01, a radio outburst occurred. The delay can only be due to the finite time required for energy to flow from the optically emitting region to a distant radio emitting region. The lack of simultaneity rules out inverse Compton emission as the mechanism for the optical radiation.

The authors of Ref. 1 report that regular observations of the quasi-stellar object 0420-01 (redshift of $z=0.915$) have been made using the 120 ft (37 m) Haystack antenna. It has also been regularly observed photographically from the University of Florida. Outburst in both optical and radio radiation have occurred, but the radio outburst is 2.2 years after the optical outburst.

The simplest explanation for the delay is that a source of energy (beam of particles or photons or shock wave) propagate from the optical outburst to a distant region where it triggered the radio outburst. The optical emission cannot be due to Compton scattered radio photons associated with the radio outburst. Both radio and optical emission are probably caused by synchrotron emission in physically distant regions having different magnetic fields.

[1] Dent, W.A., Balomek, T. J., Smith, A. G. and Leacock, R.J., 'The observation of a correlated, time-delayed radio-optical outburst in the quasar 0420-01,' *Astrophys. J.*, **227**, L9-L10 (1979).

T 18

MISSIONS TO SALYUT 6

By Gordon R. Hooper

PART 7

Continued from the May issue]

Soyuz 31

On 26 August 1978, at 14.51 (all times expressed in GMT), the Soviet Union launched Soyuz 31, callsign Yastreb (Hawk) carrying a two man crew. Flight commander was Colonel Valery Bykovsky, a veteran of the Vostok 5 and Soyuz 22 missions, while the cosmonaut researcher was Lt.-Colonel Sigmund Jähn of the GDR, a rookie. Back-up crew were Viktor Gorbatko and Eberhard Kollner.

The GDR delegation present at Tyuratam/Leninsk for the launch was headed by Heinz Hoffmann, a member of the SED Politburo. Before the launch, Vladimir Shatalov said the Soyuz 31 crew would carry out a series of medical, biological, scientific and technical experiments prepared jointly by Soviet and GDR scientists. They would then return to Earth with the results of their experiments, together with the experimental data obtained during the previous month by Vladimir Kovalyonok and Alexander Ivanchenkov onboard Salyut 6.

The flight programme included medical, biological and technological experiments, research into physical processes and phenomena in the Earth's atmosphere, and also visual observations and photography of various parts of the Earth's surface and oceans with the object of studying natural resources. Jähn would do the photography using the MKF-6M camera which had been designed by Soviet and GDR specialists, and made at the Carl Zeiss Jena works in the GDR.

In all there were more than 20 joint experiments, including:

- *Syomka* : The photography of various areas of the Earth by means of the MKF-6M camera;
- *Berolina* : Materials processing;
- *Audio* : The testing by means of highly sensitive equipment of a person's ability to distinguish the most subtle nuances of sound in outer space;
- *Vremya* : Obtaining new data about Man's ability to react speedily under the conditions of weightlessness to the commands given to him by an operator or machine;
- *Reporter* : Research into the conditions of photography inside spacecraft and testing of various types of photographic film.

On 27 August, MCC awakened the crew after a sleep period lasting 10 hours – three hours more than originally planned. By 12.00 Soyuz 31 had completed 14 revolutions. Following an orbital correction, the parameters of the ship's orbit were 326 x 271 km (203 x 168 miles) x 90.2 min x 51.6°.

Docking with the Salyut 6 station took place at 16.37 and 37 seconds, over an area to the North of Lake Balkhash. During all stages of the approach and docking, "the systems of the orbital station and Soyuz 31 functioned faultlessly; both crews performed their tasks with complete mutual understanding."

Gifts for Cosmonauts

Seconds before the connecting hatches opened, the TV cameras onboard Salyut 6 showed Vladimir Kovalyonok holding presents for the visitors. The gifts included a Russian doll, bread and salt, and a toy "Mishka" bear, the symbol of the 1980 Moscow Olympics. "We are looking forward to a joyful moment" Kovalyonok told MCC. "Once again an international crew is going to visit us. We'll be meeting old friends and turning a new page in the systematic continuation of the Intercosmos programme."

Then Jähn entered the Salyut. "Hello friends. Privates! Greetings!" he said, and then embraced Kovalyonok. He was carrying presents in one hand, and a special issue of *Izvestia* in the other. Bykovsky said: "We were firmly determined to join you and we were convinced that we'd be meeting you here today. Do you remember how we rehearsed every thing back on Earth? Well, what am I to say now about my feelings at this moment; you know you are real heroes, having stopped up for so long."

Jähn then said, "I've a few small presents for you. First a watch for each of you, made specially for this mission. It's inscribed "a souvenir of the USSR-GDR space flight." Bykovsky was genuinely surprised by the gift. "I didn't know anything about this," he said. Other presents included a miniature book about the GDR, and a toy Berlin bear.

Leonid Brezhnev and Enrich Honecker sent a congratulatory message to the four cosmonauts, and they sent an immediate reply. *Tass* reported that the Soyuz 31 crew would, upon completion of their mission, return to Earth in the Soyuz 29 spacecraft, leaving the fresher Soyuz 31 craft behind.

On 28 August, the four cosmonauts began work together at 09.30, and continued until 20.00. They carried out cardio-vascular checks with the aid of the Polinom-2M, Rheograph, and Beta apparatus. Electro-cardiograms, rheograms, ballistographs and other indicators were recorded during the tests. The cosmonauts also began Splav and Kristall experiments.

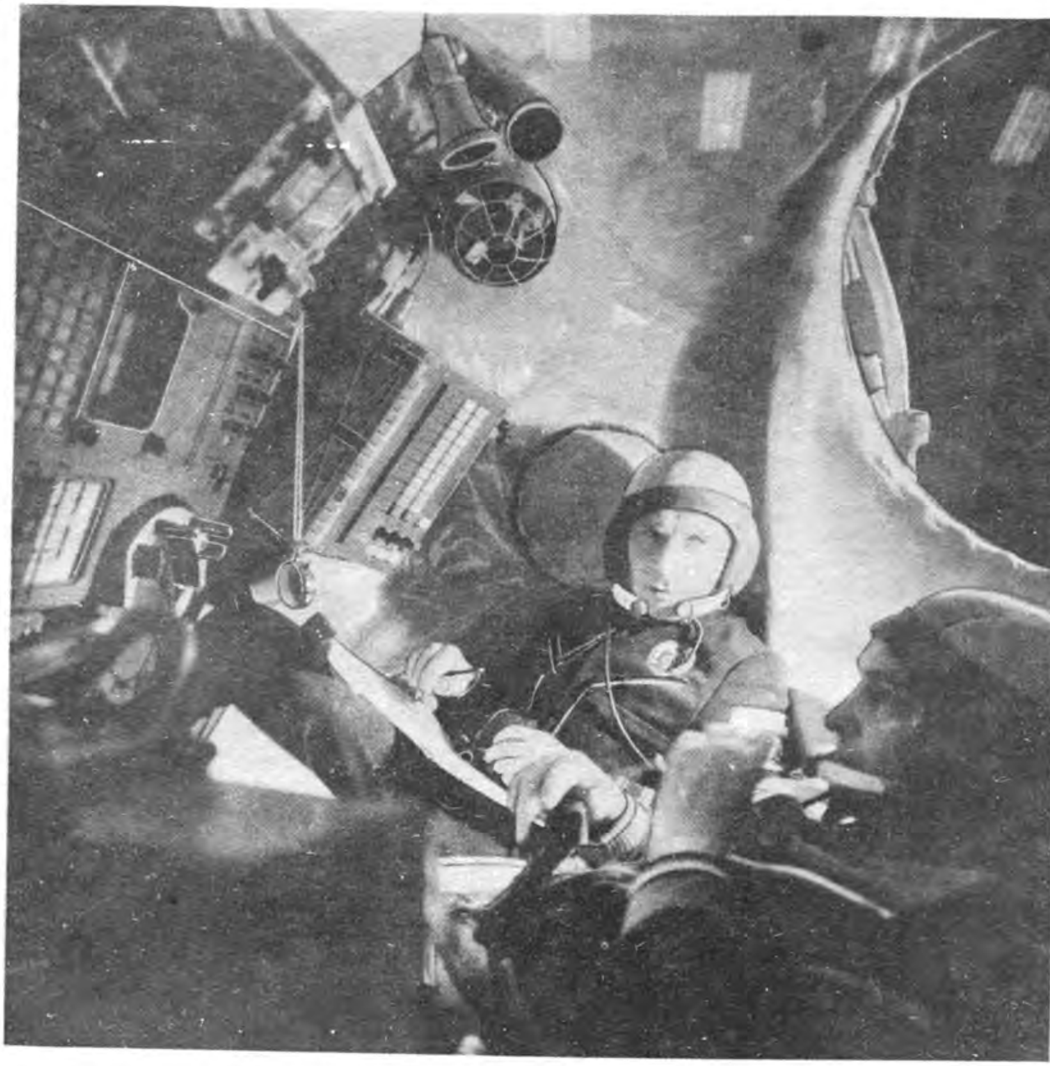
They also began the Rech (Speech) experiment, in which Jähn had to repeat an agreed phrase – the number 226 in German – during the communications sessions with Earth for the whole duration of the mission. The tone, volume, rate and other characteristics of his speech would then be compared to detect the relationship between how he felt in conditions of weightlessness and what his voice sounded like. This would aid scientists in assessing how people feel in space, and how they can live normally.

Another experiment, called Audio was also begun, to investigate for the first time during a Soviet space flight whether the hearing of a cosmonaut alters in outer space. The experiment was explained by Jähn in a TV report. Preparations for the experiment, together with other medical experiments were made at the Koenigsbrueck Aviation Medical Institute.

Audio Experiment

The scientific director of the Audio experiment, Lt. Colonel Dr. Werner Proehl of the GDR Institute for Space Medicine explained the operation of the experiment. The cosmonauts measured each others hearing using the Elbe audiometer, made in the GDR, which measured the subjects threshhold for different frequencies. The volume of each frequency was increased until the subject began to hear it. Analysis of the results produced curves on graph paper, and these curves, known as audiograms, would be analysed on Earth and compared with pre-flight data to assess any changes.

The second part of the Audio experiment consisted of measuring the sound levels in various parts of the spacecraft, in order to find the quietest part in which to actually carry out the hearing tests. A precision impulse instrument made in the GDR was used for this.



Cosmonauts Valery Bykovsky and Sigmund Jähn in training at the Yuri Gagarin Cosmonauts Space Centre before their flight in Soyuz 31.

Novosti Press Agency

On 29 August, Kovalyonok and Ivanchenkov took blood samples in the morning by means of a micro-analyser, to be delivered to Earth for lab tests. During the day, two experiments were carried out in the Splav and Kristall furnaces, together with a series of joint bio-medical experiments to study the development of micro-organisms in weightlessness.

One of these, "sewing of micro-organisms", developed by the Koenigsbrueck Aviation Medical Institute has a direct relation to terrestrial technology, specifically that concerned with micro-biological industrial enterprises. Earth's gravity affects the geometry of such important formations as floccules, consisting of micro-organisms and organic polymers. The process of "sewing" such polymers is an important part of the technology of obtaining many medicinal preparations.

Another biological experiment, "tissue culture" was also begun. Its aim was to study the influence of space flight conditions on the flow of elementary bio-processes in a live cell.

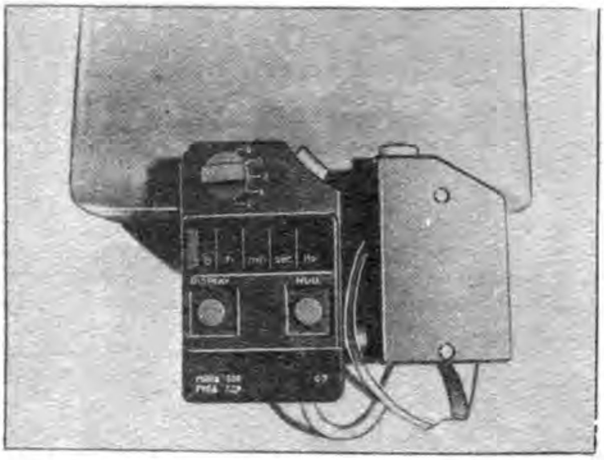
Jähn and Bykovsky carried out the first part of the "Reporter" experiment, using a GDR-designed Praktika EE-2 camera. They collected complete information on methods of photography inside space vehicles and also from onboard the Salyut, in preparation for recommendations on the use of different types of photographic film in space conditions.

Press Conferences

The four cosmonauts held a press conference, during which Jähn was asked what his feelings were. "I'm very happy," he said "in that I'm the first German to take part in a space flight. I regard my participation in it as a display of friendship and co-operation between the Soviet Union and the GDR and between their peoples. I'd like to express my gratitude to the leaders of our parties and countries, comrades Erich Honecker and Leonid Brezhnev for this honour, and the confidence shown in me, and for their warm greetings to the crew and to all the comrades who have prepared this flight. As for my physical shape, I'm quite fit and I'm astonished how quickly I've adapted to the state of weightlessness."

A GDR Radio report revealed that following the return of Bykovsky and Jähn to Earth, Kovalyonok and Ivanchenkov would manoeuvre Soyuz 31 from its position at the aft docking unit to the forward docking port. This would then leave the station ready to receive another Progress craft.

At a press conference in Moscow, Viktor Blagov told newsmen that the operation would take three to four days. First, over two days, the crew would partially isolate Salyut



Instrument used during the Soyuz 31/Salyut 6 experiment 'Vremya' which measured speed of reaction and the ability to estimate times and to compare two periods of time. Timing accuracy 1/100th of a second. Experiment designed by GDR Flight Medicine Institute Koenigebrueck; instrument built by the Ruhla Clock and Watch Company.

Panorama DDR/Zentralbild

6, and would then enter Soyuz 31. The spacecraft would then undock and follow Salyut 6 at a distance of 100-200 m (328-656 ft), while the station was turned 180° to point the forward docking port towards Soyuz 31.

MCC would then command the Soyuz 31 vehicle to redock, the entire undock/redock operation taking approximately 90 minutes, i.e. one revolution. Blagov emphasised that the operation could have been undertaken earlier, but there had been no need for it. However it was now considered necessary, because the rear docking unit had to be prepared for the next Progress.

On 30 August, the greater part of the day was devoted to experiments under the programme for environmental research and exploration of the Earth's land surface and oceans. The photography was carried out using the MKF-6M. A Polarization experiment was conducted, with the aim of determining the influences of landscape and atmospheric conditions on the accuracy of the guidance of scientific equipment.

Factory Experiments

Professor D. S. Grishin, director of the technological experiments explained that the experiments with the Splav furnace comprised the Berolina-S1 and S2. The object of the Berolina-S1 was to boil beryllium-thorium glass. A more uniform and higher-quality glass was expected to result, for possible use in optical devices such as telescopes, microscopes, cameras and so on. Berolina-S2 differed from previous experiments in that crystals of the semi-conductor element bismuth-antimony were produced using a special quartz matrix-programmed temperature reduction process, in which the crystals obtained would be of value both for scientific research and for constructing various kinds of equipment.

There were also two Berolina experiments for use in conjunction with the Kristall furnace, which used a different crystallisation method to Splav. The Kristall used a computer-controlled mechanical retraction device which slowly withdraws the ampoules from the high temperature zone of the oven in its cooling process.

In the Berolina-K1 experiment, the cosmonauts grew lead-tellurium crystals for the first time by sublimation. The source material was placed at the heated end of the capsule and as it evaporated, it gradually passed to the cold end where it cooled and crystallised on a seed crystal. In the Berolina-K2 experiment, bismuth-antimony crystals were also grown, as in the Berolina-S2, the difference being the method of cooling, i.e. mechanical retraction. In this way, by using the same materials, but different furnaces, the best crystal growing method could be ascertained.

On 31 August, under the programme of medical experiments, the crew studied the dynamics of their subjective sense of time and taste. A joint bio-medical experiment entitled "metabolism" was completed. They also completed tests to see how bacteria develop in space. Micro-organisms brought from Earth had produced new generations, and the purpose of the experiment was to determine what genetic changes had occurred.

Another experiment called Biosfera (Biosphere) involved studying the Earth's environment. During this, the cosmonauts made visual observations and photographed the Earth and its oceans, dust and smoke pollution of the atmosphere, and various meteorological phenomena. Bykovsky and Jähn used the MKF-6M, Pentacon-6 and Kaffka-E2 cameras.

On 1 September, Bykovsky and Jähn completed the majority of their programme of scientific experiments. They studied the effects of space flight on their gastatory sense and hearing, continued the Biosfera experiment, and carried out other joint bio-medical experiments. In addition, they resumed their Berolina and Kristall experiments, and conducted an Aurora Borealis experiment based on observations by Yuri Romanenko and Georgi Grechko.

Radio Berlin reported that the Soyuz 31 crew had

Demonstration model of Praktica EE 2 camera used by cosmonauts in the experiments 'Biosphere' and 'Reporter' aboard the Salyut 6 space station.

Panorama DDR/Zentralbild

Instrument used in the experiment 'Audio' being tested by Dr. Ing. Wolfgang Niehoff (left) of VEB Präzitronik, Dresden, and Dipl. Ing. Gerhard Johw of VEB (MeBelektronik, Dresden.

Panorama DDR/ Zentralbild

brought a 4 kg (8.8 lb) food parcel from Earth to the Salyut cosmonauts. It contained such delicacies as fresh onions, garlic, lemons and apples, milk, soup, honey, pork, Bulgarian peppers, and ginger-bread. It was all specially prepared to keep for up to 19 months.

Preparing to Return

On 2 September, the cosmonauts' working day began with a telegram saying "Good Morning! Please accept our congratulations on your 80th day in orbit, and confirm the list of equipment returned." During the day, Bykovsky and Jähn prepared for their return to Earth. They completed the Berolina experiments to produce bismuth-antimonide crystals, and prepared the Soyuz 29 capsule for its return flight. They transferred 25 samples containers to the descent module, and in the afternoon, they tested the orientation and control systems of the spacecraft, firing the engine for approximately five seconds.

It was reported that the recovery teams were already in position in Kazakhstan, and that preparations were well underway at Tyuratam/Leninsk for the launching of the Progress 4 craft.

In an interview, Yuri Grigoryevich Teplakov, duty flight controller, explained the reason for transferring the "lodgements" from Soyuz 31 to Soyuz 29. "Lodgements are the cosmonauts shaped armchairs, which are specially made and moulded for the person in question. The cosmonauts needed them so that they can more easily bear the high g-loads which occur throughout the descent. That is why the lodgements have been transferred."

"The centring weights have also been transferred," he continued. "They are also essential to the crew for the correct centring of the craft....The centring weights are located under the armchair. The centring of the craft is specially calculated in relation to the weight of the cosmonauts and the weight of the equipment that has been transferred. It is necessary in order to land in the spot determined by the ballistic experts where the recovery group is waiting. A small deviation from the correct centring – a very small error – could have a quite significant effect during landing, resulting in an overshoot, or an undershoot, and certain unfortunate conditions could be related to this. Therefore, everything is kept ideally precise from the point of view of weight and from the point of view of the position of the cosmonauts in the descent capsule."

Replying to a question about the series of tests carried out by the cosmonauts, Teplakov said "The flight programme envisaged the holding of a predescent test with the system of orientation and guidance of the craft's motion. What does this mean? It means that during the day the cosmonauts carry out the same operations that will be carried out during the descent operation. They are carried out in the same conditions in which the engine will be switched on tomorrow."

"The craft will be manoeuvred in the appropriate manner. The relevant parts of the orientation system will be selected. The engine will be switched on. After all, Soyuz 29 has now been flying for quite a long time, more than 70 days, and the systems have, nevertheless, been mothballed. They have now been demothballed and they have to be tested. This is exactly what the cosmonauts have been doing. This is exactly what they have done....the dress rehearsal was successful and as it should have been. There were no faults in the onboard systems. The craft's onboard systems are more or less ready for the descent, just like the cosmonauts themselves."

Asked why the crew were returning in Soyuz 31, Teplakov said: "Well each craft and the systems installed in it have their own definite lifetime for work, and precisely now after 70 days of flight, the lifetime – it cannot be said that it has been exhausted, but the cosmonauts are exchanging their craft, so that the fresher craft remains behind."

Return of Soyuz 29

On 3 September, the cosmonauts began work at 03.00. They checked the Soyuz 29 systems before Bykovsky and Jahn entered it and sealed themselves in. Undocking took place at 08.23 and 18 seconds with retrofire at 10.52 and 8.8 seconds. Separation of the modules occurred at 11.10 and 32 seconds.

Touchdown took place at 11.40 140 km (87 miles) South East of Dzhezkazgan. The recovery team reached the descent module some two minutes later, "with its dark sooty sides still hot." The crew had already climbed out and were sitting down on the ground. They then carried out the traditional task of autographing their capsule with chalk.

On 4 September, the cosmonauts held a press conference at Tyuratam/Leninsk during which they revealed that they had brought to Earth over 100 test samples and other equipment, including six film cassettes from the MKF-6M camera.

Asked what he would take to Kovalyonok and Ivanchenkov if he made another flight, Bykovsky said that he would certainly take what the main crew had asked for – onions; garlic; letters from home and their friends. Jähn added that he would also take along some fresh fruit and perhaps even a bottle of beer.

Meanwhile, onboard Salyut 6, following breakfast and their exercises, the cosmonauts checked the station's systems and equipment and got their documentation up to date. They also carried out visual observations and photography of the Earth, and conducted biological experiments. The onboard parameters were temperature 20°C (68°F); pressure 790 mm on the mercury column.

On 5 and 6 September, the day's programme again included bio-medical experiments and systems checks, together with Earth observations and photography. Bykovsky and Jähn, back at Tyuratam/Leninsk, were undergoing medical check-ups and flight de-briefing.

On 6 September, Radio Berlin gave further details of the "Speech" experiment. It involved the cosmonauts using precisely the same phrases during communications sessions. These phrases were then recorded and cut up into small frequency ranges and analysed. They were then expected to show to what extent speech is dependent on the psychological state of the speaker. The aim of the experiment was to highlight any work activities which exposed cosmonauts to certain types of stresses and strain.

Undock-Redock Operation

On 7 September, impressive undock-redock operation to switch the Soyuz 31 craft to the front docking port was carried out. The Salyut was put into a gravity-gradient stabilisation mode and the crew then transferred to the Soyuz and undocked at 10.53 over the Southern Atlantic, somewhere over the Gulf of Guinea. Soyuz 31 backed away from the Salyut to a distance of 100-200 m (328-656 ft) and maintained a station-keeping flight.

MCC had intended to command the Salyut to fire its thrusters to rotate 180°. This would have the effect of facing the forward docking port towards the Soyuz. However, in execution, the orbital mechanics associated with the gravity gradient starting point when the Soyuz was still docked effected a 90° pitch manoeuvre once the Soyuz undocked. Therefore, thrusters were only required to complete the remaining 90° of the turn.

With the forward docking unit correctly aligned, MCC commanded the Soyuz vehicle to re-dock, the operation taking place somewhere north east of Lake Balkhash in the Soviet Union. The cosmonauts then checked the airtightness of the seal before crossing over into the Salyut. The Soyuz 31 craft was then re-mothballed.

On 8 September, Kovalyonok and Ivanchenkov underwent complete medical check-ups. They tested their cardiovascular system's reactions to simulated hydrostatic pressure using the Chibis suit. They also used the Polinom 2M, and tested vascular tension. Kovalyonok and Ivanchenkov's blood pressure was 130/65 and 135/60 respectively, and pulse rate 77 and 68.

On 9 September, they had a day of rest. Although no experiments were undertaken, there was still plenty of reactivation work to do following the re-docking operation. They also carried out Earth observations work. This work was continued on 10 September, with particular emphasis on glaciers in the Pamir Mountains.

On 11 September, Bykovsky and Jähn returned to Star Town. Onboard Salyut 6, Kovalyonok and Ivanchenkov worked on biological experiments and prepared scientific apparatus for future experiments. They were also busy in photographing the territory of the Soviet Union and the world oceans, acting on the instructions of the State Nature Centre.

Observing Sea Colours

It was reported that MCC were constantly asking the cosmonauts to observe the changes in the circulation of the currents in the area of the southern islands of the Soviet Union. Scientists were very interested in evaluating the colour of various parts of the ocean. The station carries a special colour table, and the cosmonauts often referred to this table when reporting on their observations. This made it possible to give a more objective assessment of the degree of information carried by the data gathered. By assessing the shade of the colour, scientists can draw conclusions on plankton and seaweed distribution, and can predict the fishery yields of various parts of the oceans.

During their mission, the cosmonauts had helped fishing vessels in the eastern seas of the Soviet Union to navigate more precisely, and reported the furthest distribution of plankton, and this made it possible to determine the most profitable locations of fish shoals.

On 12 September, the cosmonauts spent most of the day on Earth photography, concentrating on particular areas of the Soviet Union. They also observed the development and movement of cyclones, and studied the oceans.

On Earth, Bykovsky and Jähn attended a press conference held in Moscow, where they and space scientists from the GDR and Soviet Union met the press in the Central Journalists House. The press conference followed on from a reception in the Kremlin, where the two men had presented Leonid Brezhnev with a portrait of himself and the national emblem of the GDR, both of which had been taken onboard the Salyut station.

During the reception, Brezhnev presented Bykovsky and Jähn with their Orders of Lenin. In his speech, he said, "I congratulate you my dear cosmonaut friends, on your safe return to Earth and on the successful implementation of the honourable and complex tasks entrusted to you. I would like to take advantage of this occasion to convey best wishes to comrades Kovalyonok and Ivanchenkov with whom you recently parted in orbit, and who are courageously continuing their long flight.

"....It is hardly possible to mention a branch of science, of technology, or of the national economy where the beneficial effects of space exploration have not been felt to some degree. It can be said with confidence that the benefits from the exploration of non-terrestrial space will increase in the future.

"Space flights by international Socialist crews within the frame-work of the Intercosmos programme in no small way demonstrates the progress achieved in our Socialist community by the leading branches of science and technology. They gather knowledge which benefits the whole of mankind, and today when in the footsteps of Poland and Czechoslovakia, space was visited by a citizen of the GDR, I would like to stress the substantial contribution made by the socialist state of German working people to the joint work by fraternal countries in the study and conquest of space."

On 13 September, Kovalonok and Ivanchenkov continued their programme of observations and photography of the Earth. During their mission, they had photographed individual districts of Kazakhstan, Central Asia, Siberia, the Baikal-Amur region, the Soviet Far-East and the European part of the Soviet Union.

During the course of the day, the cosmonauts spoke to Bykovsky and Jähn at MCC, and began a Kristall experiment. Doctors in the medical control group reported that both men were in good health, and had a high capacity for work. The onboard parameters on Salyut 6 were: temp-

erature 22°C (72°F), and pressure 790 mm.

On 14 September, the days programme included tuning the BST-1 sub-millimetre telescope. They continued their Earth observations and reported seeing an erupting volcano in the Canary Islands and a large dust storm in the Sahara, which had changed direction and was now headed for the Central Atlantic.

In reply to a listener's question about solar flare radiation hazards, Radio Moscow reported that Soviet cosmonauts carried individual dosimeters to monitor their irradiation dose, and automatic measurement onboard the station was telemetered to Earth to a special radiation working group. In the event of a really dangerous situation building up, they would sound the alarm. But, it was pointed out, the Salyut orbital inclinations and altitudes were chosen in such a way as to take the cosmonauts through the safest areas of terrestrial space.

On 15 September, the two men took their second shower of the mission. They took care to wait for a period of good TV and radio reception before beginning. Ivanchenkov was seen wearing a "transparent plastic mantle and wearing a mask and goggles" to cope with the effects of weightlessness on water. Also during the day, they completed another Kristall experiment, measured the sub-millimetre radiation of the Earth's atmosphere using the BST-1 telescope, and continued their usual Earth observations work, passing on information about the weather to meteorologists at MCC.

Observing a Lunar Eclipse

On 16 September, the cosmonauts studied a full lunar eclipse using the BST-1 to observe the Moon's glow in the UV range, and photographed various phases of the eclipse. They reported that they could still distinguish craters and other features on the Moon despite the small shadow. According to Academician Petrov, the way light is diffracted in the Earth's atmosphere and then reaches the Moon during an eclipse could give information on how solar energy interacts with the upper layers of the Earth's atmosphere.

On 17 September, the crew were given a day of rest. They examined the results of recent experiments and prepared scientific apparatus for further ones, as well as carrying out sanitary and hygiene measures. During the day, the crew observed a second cloud layer above the atmosphere – a phenomenom first observed by Romanenko and Grechko during their flight over the Equator. Kovalyonok and Ivanchenkov believed the second layer, like the first, might cover the entire Earth. They also observed a dust storm over the Soviet Union. It appeared around the Mangyshlak Peninsula where a high wind lifted the dust from a large area and carried it North to reach the mouth of the Volga.

On 18 September, the cosmonauts had their second day of rest, during which they had a thorough medical check-up which revealed that their blood pressure and pulse were normal. After the medical, they carried out smelting operations, Earth photography, systems checks and plant studies.

On 19 September, they checked their scientific apparatus and carried out maintenance work, visual observations and photography of the Earth. It was reported that in the previous few days they had observed the formation of cyclones and the eruption of volcanoes.

On 20 September at 06.17, Kovalyonok and Ivanchenkov broke the 96 days and 10 hours record set by Romanenko and Grechko, and Romanenko himself was one of the first to congratulate the crew. During the day, the cosmonauts carried out medical experiments using the veloergometer to determine and forecast the condition of their cardio-vascular systems, which were recorded by the Polinom-2M, Rheograph and Beta apparatus. The day's programme included a study of the tone of the blood vessels and separate muscle groups, "which bear an insignificant load in conditions of weightlessness." A further Kristall experiment took place in the afternoon.

Medical Report

Radio Moscow broadcast an interview with R. V. Dyakonov, the crew's doctor, who said that the crew were doing their work well. Although their health was excellent, it had been affected by weightlessness. There had been a certain loss of weight, with Kovalyonok having lost less weight than Ivanchenkov. This had occurred not just because of weightlessness, but also because of the complicated scientific experiments carried out daily.

Weight changes in orbit were of particular interest to scientists. At certain stages in the mission, there had been a certain stabilisation, a relative gain in weight. However, this weight was within the limits forecast by experts, taking into account the preventative measures taken onboard the station.

On 21 September, further visual observations and Earth photography was continued, as were experiments on plant growth and smelting. One Kristall experiment was completed, and another begun. Studies were made of the Earth's ozone layer using the BST-1 sub-millimetre telescope.

On Earth, Bykovsky and Jähn accompanied by Shatalov arrived at the Schönefeld airport in Berlin. They were welcomed by the GDR Defence Minister, General Heinz Hoffman, who announced the promotion of Jähn and his back-up Eberhard Kollner to Colonel. In Berlin, the cosmonauts received a heroes welcome, and were decorated by Enrich Honecker. Bykovsky and Jähn were awarded the title of Hero of the GDR, and the Order of Karl Marx. Kollner was given the GDR's highest military award, the Scharnhorst medal.

On 22 September, Kovalyonok and Ivanchenkov carried out an Earth resources photography session, and then put the Salyut into a gravitational stabilisation mode to carry out a Kristall experiment. They had been conducting Kristall experiments nearly every day. A medical examination showed that the men were in good health. The blood pressure of Kovalyonok and Ivanchenkov respectively was 110/65 and 115/68 and pulse rates 66 and 70.

On 23 September, Radio Moscow reported that the day would be less strenuous than usual. They continued their biological experiments and made a TV report. During their mission, they had so far taken over 18,000 pictures of the Earth's surface.

On 24 September, a day of rest, the cosmonauts had another medical check-up, a systems check, and carried out Earth observations studies. On Earth, Bykovsky and Jähn visited the Karl Zeiss Jena works in the GDR.

Special Tools

Radio Berlin gave details of the special tools used by the cosmonauts onboard Salyut 6 for repair work and unloading. There was a special "recoil-less" hammer, which prevented injury; a special "lock-on" screwdriver; a kind of combination pliers, multiplying the force applied to them. There was also a universal power tool "which drives drills as easily as a screwdriver." It was virtually noiseless and vibration-free.

Writing in *Selskaya Zhizn*, Professor Nikolai Gurovsky, head of the space medicine department of the USSR Ministry of Health, said: "We are completely satisfied with their state of health. The cosmonauts very seldom use the first-aid kit onboard Salyut 6. They prefer to drink eleuthera bark, which is a tonic combining good food and medicinal qualities. At present, according to biotelemetric data, the crew are well and we take an optimistic view of their further activities."

Gurovsky explained that from approximately the fourth-sixth week onwards, the cosmonauts state of health stabilises, and that no problems were anticipated with Kovalyonok

and Ivanchenkov's return to Earth.

On 25 September, Kovalyonok and Ivanchenkov serviced the Salyut and continued their scientific experiments, including the growing of higher plants (such as arabidopsis) in the Phiton chamber. The Phiton experiment had begun some two months earlier. *Arabidopsis* was sown in a nutrient medium and given air and light, with the aim of producing a full cycle of development of a higher plant, from seed to seed. The experiment was connected with the future creation of ecological systems in space stations and interplanetary craft to provide the crew with oxygen and food. The effects of weightlessness on the plant as a whole could be studied, together with the effects on cells and cell material.

An American source reported that the Soviets were stressing the direct correlation between the long duration mission and the possibility of future Soviet manned interplanetary flight. "The cosmonauts have retained their ability to work, and according to their own statements, they feel they have a sufficient reserve of strength to continue to fulfill the programme," said the Soviets. "The necessity of Man's prolonged stay in weightlessness is dictated to a greater extent by the future tasks of space exploration than by the present ones. For example, a flight by Man to the planet Mars will require a 1.5 year stay in weightlessness, under the most favourable conditions."(A Novosti report had just quoted Dr. Oleg Gazenko as saying that 120 days was the present limit for Man in space).

In the GDR, Bykovsky and Jähn, together with Shatalov and Kollner, visited the Central Institute for Solid State Physics and Material Research and the Robotron electronics works in Dresden.

On 26 September, the day's programme was fairly routine, involving work with the BST-1 sub-millimetre telescope, physical exercises on the velo-ergometer and running track, and visual observations of the Earth.

Future Multiple Docking

In an article in *Sotsialisticheskaya Industriya,* Konstantin Feoktistov said that he thought it expedient to provide a Salyut orbital station with a minimum of seven or eight docking units. At present, after each cargo vehicle docked with the station it was unloaded and then undocked to provide room for the next one. This was irrational, according to Feoktistov. "When the cargo ship leaves, we lose a complete 'room' of the cosmic house, with a capacity of about 6 cu. m. Equipment and scientific instruments could be placed in there."

"But to add even one more component to the design of the Salyut," said Feoktistov, "is not a simple task. Virtually the whole surface of the station is occupied by solar batteries, windows, TV cameras and various sensors. At the active phase of the launch, the station is covered by a nose fairing, the shape and size of which also restricts the designers, and yet, I can see in the future, space stations with several 'mooring berths'. Units for specialised research – technological, astronomical and geophysical – could be docked with it. I believe that the near future belongs to such stations," he concluded.

On 27 September, the cosmonauts continued their usual Earth observations. They had observed the snow cap and glaciers in the Pamirs at the request of glaciologists. They continued an experiment begun the previous day using the BST-1 sub-millimetre telescope to carry out a series of measurements of irradiation of the Earth's atmosphere to obtain data about active local fields in the troposphere. The onboard parameters of the Salyut's atmosphere were: temperature 19°C (66°F), pressure 780 mm on the mercury column.

On 28 September, Ivanchenkov celebrated his 38th birthday, and received birthday greetings from cosmonauts Kubasov, Sevastyanov, Glazkov and others. During the day, the Salyut crew completed a routine series of experiments with the BST-1 sub-millimetre telescope, studying *Alpha* and *Beta Centaurus, Sirius* and other stars. They reported during one communications session the sprouting of a green onion shoot in one of the plant experiments.

On 29 September, MCC reported that it was exactly one year since the launch of the Salyut 6, during which the station had completed 5,765 revolutions. Onboard the crew spent the day on comprehensive medical research.

On 30 September, a scheduled rest day, the cosmonauts were given permission to continue their work with the BST-1 sub-millimetre telescope. Feoktistov reported that their spacewalk to retrieve samples mounted on Salyut's exterior had yielded interesting results. Samples brought back to Earth showed that it had "practically rained" with micro-meteors. For example, a small plate 1/16 sq. m. (i.e. 2.5 sq. in.) in area was found to have several hundred craters. It was the first time that controlled samples had been subjected to micro-meteor bombardment for such a long period.

On 1 October, the crew had their second day of rest. They talked to relatives, watched films, listened to music and spoke to oceanologists about problems they had encountered in observing underwater ridges.

The next day, they resumed their studies of the stars using the BST-1, and conducted Earth observations and photography work. They also checked the station's guidance systems in both manual and automatic orientation and stabilisation modes. Technological experiments included a new Kristall smelting operation.

On 3 October, the crew had a complete medical checkup using the Polinom 2M to check their cardio-vascular systems. The results of the examination showed the men to be in good health. Kovalyonok and Ivanchenkov's pulse rates were 72 and 70 respectively, with blood pressures of 120/75 and 125/70.

Other experiments involved a study of the dynamics of change in the station's gaseous atmosphere, and the completion of a Kristall smelting experiment which produced lead-telluride crystals.

In a communications session, the cosmonauts described a recent strange phenomenon. As they looked through the porthole, the Earth seemed to have come closer, and they could see details usually visible only at a distance of just over 300 km (186 miles). The scientists could not explain this apparent "magnifying-glass" effect, which only seemed to occur under certain conditions.

On 3 October, also, the expected cargo craft – Progress 4 – was launched from the Tyuratam cosmodrome.

Acknowledgements

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[To be continued

WE HAVE MOVED!

As from *1 May 1979* the Society's address changed to its new Headquarters building *27/29 South Lambeth Road, London, SW8 1SZ (Tel: 01-735 3160).*

Correspondents should ensure that all future communications are sent to the new address.

SHUTTLE ABORT PROCEDURES

We have received a number of enquiries from readers concerning flight safety provisions for the Space Shuttle. The questions range from abort procedures to the security of insulation tiles under re-entry conditions.

Dr. David Baker comments:

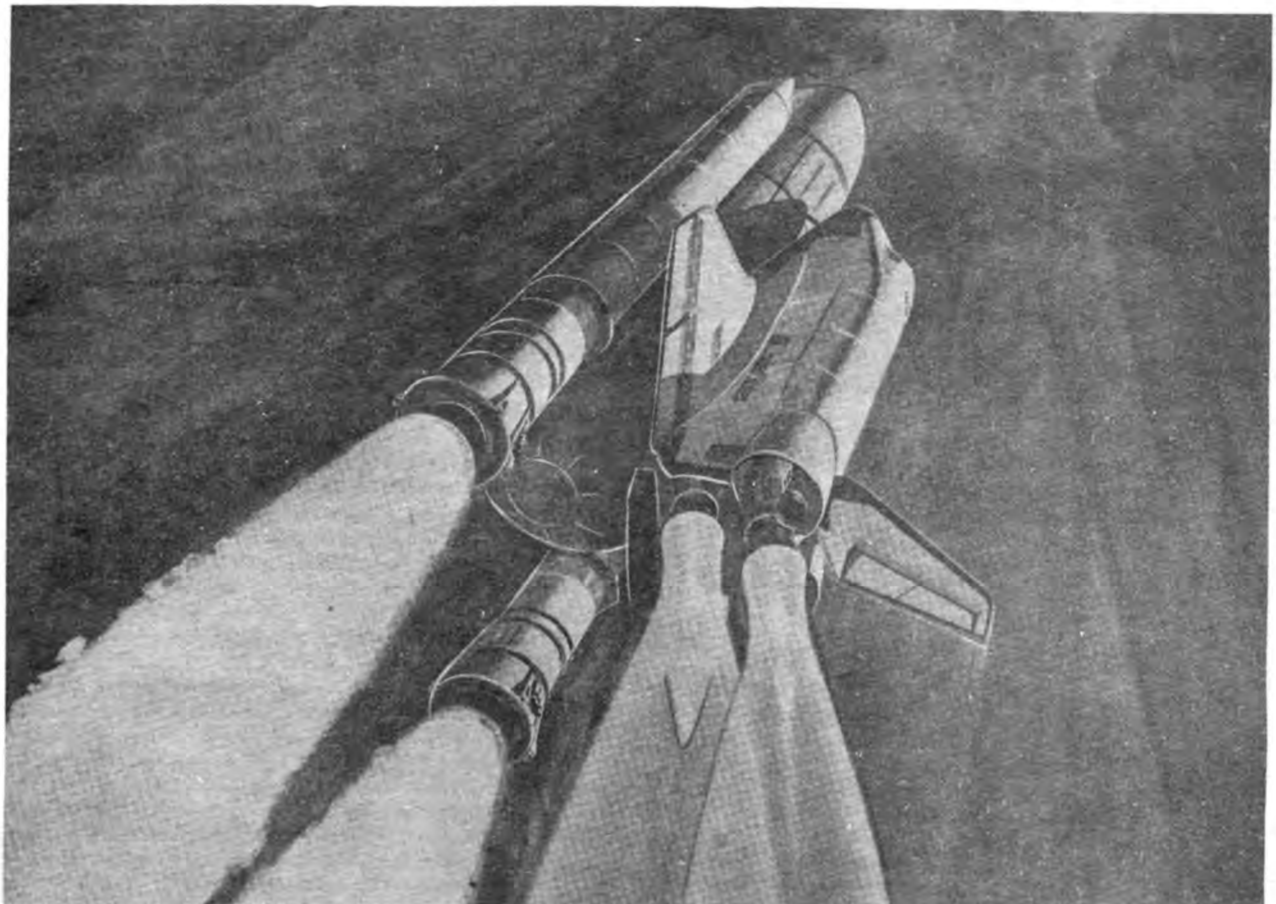
I well remember the Abort Solid Rocket Motor (ASRM) attached in concept to either side of the Orbiter fuselage, and what a joy to get rid of those lethal appendages! Each ASRM was to have been 9.4m long, 1.7m in diameter and serve to push the Orbiter to a crew abort altitude during the first 30 sec of flight, at which time they were to be released at a height of 3.5 km and a speed of 242 m/sec. This was dangerously close to a max q and the whole idea was a legacy from the ballistic recovery days.

As currently envisaged, aborts will now follow one of three contingency profiles: Return to Launch Site (RTLS), Abort Once Around (AOA), or Abort To Orbit (ATO). Under the most adverse abort conditions, the crew, payload and Orbiter are required to return intact to a conventional landing even when abort initiation occurs off the pad. Or, for the sake of this example, at 2 sec away from the support arms. SRB requirements criteria demand a nominal thrust of 2.9 million lb (1.31 million kg, or 12.9 million newtons), 5.8 million lb for the two, at 2 sec into the flight; thrust builds to a nominal 3.1 million lb per booster at about 17 sec into the flight. I have selected the 2 sec point to represent a minimum ascent energy/maximum Shuttle mass condition.

Weights vary mission to mission but for a Mission 2 trajectory, carrying a 25,000 lb (11,340 kg) payload to an elliptical, 53°, orbit, Shuttle mass at T + 2 sec would be about 4,398,052 lb (1,994,956 kg) with total thrust at 6.639 million lb (3.01 million kg). Of the total thrust, 5.8 million lb is contributed by the two SRBs with the three SSMEs at a low throttle setting. If one SSME fails, thrust would be about 6.36 million lb. This is sufficient to initiate the first, RTLS, abort mode. In this eventuality, the remaining SSMEs continue to use propellant budgeted for all three and supplement the SRB thrust profile until normal burnout 122 sec into the flight.

The RTLS abort mode requires the Orbiter/ET to ascend to at least 107 km and turn back toward the launch site in a looping manoeuvre before shutting down the two remaining SSMEs and releasing the External Tank to an ocean splashdown. Thrust from the main engines will have brought the Orbiter back to a point from which it can glide to the KSC runway. Guidance programmes in the computer control the Orbiter and return it to a position where the crew can effect a manual landing. Touchdown should occur within 20 min of launch in a worst-case RTLS abort.

The AOA option is used during later phases of the ascent trajectory when it no longer remains possible for the Orbiter to return immediately to the runway. The AOA manoeuvre is executed so as to place the Orbiter in a ballistic path that will return it to the atmosphere at the end of one revolution, or approximately 90 min after launch.



Shuttle Abort Procedures/contd.

For this example, I chose a Mission 1 trajectory so that maximum Orbiter mass would provide a worst-case posture. Here, the Shuttle would aim to carry 29.5 tonnes to an elliptical, 28.5°, orbit. For this flight, the RTLS/AOA crossover point comes at 244 sec, 122 sec after SRB jettison, when the configuration is at a height of 109 km and a speed of 2,480 m/sec. Thrust from the three SSMEs would be about 696 tonnes (6.8 million newtons).

Assuming a single SSME failure at this point, OMS and RCS engines would come on, thrust from the remaining two SSMEs would be reduced and the Orbiter track a thrust profile averaging a total 470.8 tonnes (4.6 million N) for 151 sec until RCS cutoff at an elapsed time of 395 sec. The acceleration profile would have dropped from about 1.46g at the start of the abort to a minimum 0.99 g, but back to 1.48 g by the end of RCS firing. Meanwhile, the OMS continues to assist the two SSMEs until they are cut off at an an elapsed time of 554 sec because of the 3 g limit, leaving the SSMEs to provide the final energy. Average thrust during the OMS/SSME burn phase is 469.5 tonnes (4.6 million N).

Tracking a constant 3 g acceleration curve, thrust from the two remaining SSMEs is gradually reduced until propellant depletion 560 sec after liftoff (79 sec later than nominal for an ascent) when the engines are shut down. At this point the Orbiter is 1,631 km from the launch site, 106.2 km high (having descended from a maximum height of 126.9 km), at 7,414 m/sec. Within 30 sec the ET has been separated and at about 590 sec the two OMS engines are ignited for a burn lasting 155 sec, placing the Orbiter at a height of 125.7 km, 2,983 km from the launch site, at a speed of 7,467 m/sec, 745 sec after liftoff.

From this point the Orbiter ascends to apogee and re-enters the atmosphere on a profile similar to conventional flights. The thrust shaping has retained the flight limit of 3 g and provided energy for an Orbiter speed just below the value necessary to achieve orbit. Again, on-board guidance programmes control operations until the Orbiter is through critical flight regimes and into low altitude atmospheric flight where the crew can take over and effect a manual landing. In all cases, automated procedures are considered prime due to the critical nature of abort positional values and the narrow gates through which the vehicle must pass at each phase.

The third, or ATO, abort mode, is more difficult to categorise because it embraces a wide range of possible failures from single sensor malfunction to SSME flameout; responses to varying anomalies are numerous. Essentially, ATO provides the Orbiter a capacity to burn to orbit and remain in space until a considered and timely judgement on the future conduct of the mission. It means that OMS propellant is used to achieve orbital velocity but in the event that existing on-board supplies are depleted, RCS propellant can be used to effect a retro-burn. In fact, the RCS engines themselves would be capable of de-orbiting the spacecraft from the minimum altitude likely to be achieved on a lengthy OMS manoeuvre.

It should also be understood that 15 contingency landing fields have been assigned at various locations around the globe. Also, ejection seats will be carried on the first four Orbital Flight Test missions (STS-1 to -4) for crew escape to an altitude of 21 km during launch or re-entry. If trouble should occur on the pad up to T-30 sec, the flight crew can escape along the Orbiter Access Arm at the 44.8 m level on the Fixed Service Structure (FSS) at Launch Complex 39. As part of the Emergency Exit System (EES), or slidewire, five steel wires extend from this FSS level a distance of 365 m to the ground on the west side of the pad. Each wire can support two flat-bottom baskets woven from Kevlar 29, each basket carrying two persons. Descending at a braked average speed of 10 m/sec escapees would shelter in bunkers designed to survive the blast of a possible explosion in the External Tank/SRB assembly. The Orbiter Access Arm is retracted at T-30 sec and the escape facilities are no longer available.

Regarding tile application, fitment tests are conducted during attachment and checks made later by applying loads considerably beyond those calculated to be experienced during ascent or re-entry. X-rays are taken of the bond line and suction pads pull and tug the tiles with observed tile motion during this operation indicating the integrity of the bond. It should be recognised that tile problems with Orbiter 102 during the pre-ferry flight test earlier this year were related only to temporary tiles or tiles simulating the flight articles. No trouble has been experienced with the adhesive on flight qualified tiles.

BIS DEVELOPMENT PROGRAMME

MEMBERS WITH ARTISTIC ABILITIES

The response to our appeal for members with artistic abilities willing to help the Society with the preparation of drawings and other items has been most satisfactory – about twenty members have come forward – and we should like to extend our most grateful thanks to all those who have done so. Some of the projects already notified to those willing to participate have been the new Daedalus decal, a design for advertising the Society for use with our franking machine, designs for our new T-shirts and some preliminary designs in connection with the Society's 50th anniversary.

Members who have not yet responded but who feel they would like to participate are cordially invited to come forward. This work will be particularly appropriate for overseas members who will thus be able to participate more directly in Society activities.

REVIEWS PANEL

The Society is expanding its Reviews Panel (see note on page 236 of the May issue of *Spaceflight*) to extend its cover of scientific and technical works on astronomy and space. This also is an area ideally suited to participation by overseas members.

Members who feel that they have the necessary qualifications and who would like to be included are invited to notify the Executive Secretary.

DAEDALUS BLUEPRINTS

The Society is offering for sale a limited number of sets of "blueprints" of the starship designed by the Project Daedalus Study Group.

The three vehicle drawings concerned are the geometry of the complete vehicle (Drawing D-001) shown on page S106 of the Project Daedalus final report, the vehicle first stage configuration (D-002) on page S93), and the vehicle second stage configuration (D-003) on page S94.

These are the most detailed Daedalus drawings in existence. Two (D-002 and D-003) will be supplied in A3 size i.e. approximately 33" x 24" or 85 cm x 60 cm, and D-001 at 22" x 19" or 56 cm x 48 cm. They will be ideal for display purposes, or as a guide to model making.

The blueprints are available, at a price of £2.00 ($4.00) post free for the set of three drawings, from the Executive Secretary, British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ.

SATELLITE DIGEST - 128

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed summary of the information presented can be found in the January 1979 issue, p. 41.

Continued from June issue.]

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site launch vehicle and payload/launch origin
Meteor 2 (4) 1979-21A 11288	1979 Mar 1.78 500 years	Cylinder + 2 panels + 2 antennae 2750?	5 long? 1.5 dia?	837	896	81.22	102.33	Plesetsk A-1 USSR/USSR (1)
Progress 5 1979-22A 11292	1979 Mar 12.241 22 days 1979 Apr 3	Sphere + cone- cylinder + antennae 7000?	8.0 long 2.2 dia	183 261 294	256 293 325	51.65 51.62 51.62	88.83 89.99 90.65	Tyuratam A-2 USSR/USSR (2)
Cosmos 1080 1979-23A 11294	1979 Mar 14.45 14 days (R) 1979 Mar 28	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	167 160 151	292 220 239	72.85 72.85 72.85	89.14 88.33 88.43	Plesetsk A-2 USSR/USSR (3)
Cosmos 1081-1088 1979-24A-H 11296-11303	1979 Mar 15.12 10 000 years	Spheroids? 40?	1.0 long? 0.8 dia?	1406 1425 1444 1463 1466 1465 1466 1466	1455 1466 1466 1467 1483 1506 1525 1548	74.03 74.03 74.02 74.02 74.03 74.03 74.03 74.02	114.60 114.82 115.03 115.25 115.46 115.71 115.92 116.18	Plesetsk C-1 USSR/USSR (4)
1979-25A 11305	1979 Mar 16.77 6 months	Cylinder 13300 fuelled?	15 long? 3.0 dia	159	245	96.39	88.58	WTR Titan 3D DoD/USAF (5)
1979-25B 11306	1979 Mar 16.77 60 years			619	628	97.23	97.22	WTR Titan 3D DoD/USAF (5)
Cosmos 1089 1979-26A 11308	1979 Mar 21.18 1200 years	Cylinder 700?	1.3 long? 1.9 dia?	971	1003	82.97	104.90	Plesetsk C-1 USSR/USSR (6)
Cosmos 1090 1979-27A 11313	1979 Mar 31.45							Plesetsk A-2 USSR/USSR

Supplementary notes:

(1) Fourth of the second generation of Soviet Meteor type weather satellites returning cloud cover photographs.

(2) Unmanned supply craft carrying food, equipment and fuel to the crew of Salyut 6. Launched at 0547 UT, Progress 5 docked with the aft docking unit of the station on Mar 14. Among the items carried was a TV receiver to allow reception of pictures from the ground. Progress 5 re-entered the Earth's atmosphere on command over the Pacific Ocean.

(3) Manoeuvrable reconnaissance satellite. Two objects separated from it during Mar 22 and a further one at the time of recovery. Orbital data are at 1979 Mar 15.1, Mar 19.2 and Mar 27.4.

(4) Multiple launch of eight satellites, possibly for military communications. One orbit is shown for each satellite.

(5) "Big Bird" type reconnaissance satellite and ferret sub-satellite. Launched one year exactly since its predecessor (1978-29A), the main vehicle will be de-orbited after six months of operation.

(6) Cosmos 1089 is probably a navigation satellite.

Amendments:

1969-107A, Cosmos 315 decayed 1979 Mar 25, lifetime 3382 days, the event occurred over Canada.

1979-7A, SCATHA – add a second orbit of 27530 x 43264 km, 7.81 deg, 1416.1 min. Orbital data are at 1979 Feb 1.4 and 1979 Apr 1.9.

1978-113A, add a second orbit of 35774 x 35801 km, 2.22 deg, 1436.0 min. Orbital data are at 1978 Dec 14.8 and 1979 Mar 31.6.

1978-113B, add a second orbit of 35776 x 35796 km, 2.30 deg, 1436.0 min. Orbital data are at 1978 Dec 14.8 and 1979 Feb 28.8.

1978-116A, amend object number to read 11153.

1979-8A, Cosmos 1074 was recovered 1979 Apr 1 after 60 days. The craft was probably related to the manned space programme and the flight represents an extended test prior to its use as a vehicle to carry crews to Salyut type stations, in a similar way to the mission of Cosmos 613 (1973-96A). Six fragments were left in orbit.

1979-15A, Ekran – add orbital details as follows, 35635 x 35935 km, 0.34 deg, 1435.9 min. The object number is 11273.

1979-19A, Cosmos 1079 – delete last month's supplementary note: the satellite was recovered 1979 Mar 11 after 12 days.

OBITUARY

PERCIVAL NORMAN WEEDALL

Percival Norman Weedall, who died recently at the age of 64, was one of the longest serving Members of the British Interplanetary Society. He was a pre-War Founder Fellow of the Society, and until the transfer of the Headquarters from Liverpool to London in February 1937, he had been Honorary Librarian of the Society and a member of the Council.

Norman was one of the "Few" who were in attendance at the first official Meeting of the BIS held in Room 15, 81 Dale Street, Liverpool on 13 October 1933, at the Office of H.C. Binns, Esq.

SPACE AFFAIRS

- Government • Policy
- International • Industry
- Economics

A new series in which we invite readers at home and abroad to discuss the political and economic trends which affect our future in space. As well as acknowledging achievement, we seek to throw light upon areas where opportunities are being lost through want of proper support. Brief notes of up to 750 words will be welcomed. Please address all contributions to: The Executive Secretary, British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ.

The Department of Industry

So hidden in the bureaucratic labyrinths of Whitehall are Britain's interests in Space that we thought it appropriate to start by summarising the responsibilities of the Department of Industry and its interaction with the European Space Agency, as they applied under the former Labour Government.

"The Department of Industry is responsible for government policy towards and sponsorship of the British space industry. The aim is to develop an industrial, technological and commercial capability sufficient:

- *to maintain Britain as a fully competent partner in international space projects*
- *to meet the needs of national customers*
- *to win a significant share of new markets for space equipment as they develop.*

"To achieve this aim the Department of Industry provides support for space technology research and development in two ways:

- The Department funds the major share of the United Kingdom contribution to the European Space Agency (ESA), as a result of which ESA places contracts with British firms. The Science Research Council provides the United Kingdom contribution to ESA's Science Programme.
- The Department jointly funds with industry a small selective industrial programme of space technology research and development. The Department also funds a supporting programme in the Royal Aircraft Establishment, Farnborough."

Britain and the European Space Agency

The European Space Agency was formed in 1975 to promote and provide, for exclusively peaceful purposes, European cooperation in space activities.

ESA member states are:

Austria*	Ireland
Belgium	Italy
Canada*	Norway*
Denmark	Spain
France	Sweden
West Germany	Switzerland
Holland	United Kingdom

Britain played a leading role in the setting up of the European Space Agency and in the formulation of the programmes which the Agency is currently undertaking.

* *Observer status only.*

Membership of ESA:

- offers the best prospects for strengthening the British space industry, both technologically and commercially, by blending it into a European force capable of competing in world markets.
- provides British firms with the opportunity of taking part in a wide variety of space projects which would otherwise be too costly for Britain to undertake alone.
- avoids wasteful duplication of effort within the European space industry.

European Space Programmes

British firms play an important part in the Agency's programmes. These include:

Communications satellites

OTS Orbital Test Satellite for communications experiments. Launched in May 1978.

ECS European Communications Satellite developed from the OTS design for use in a European regional satellite communications system. Planned for launch in 1981.

MAROTS Experimental and pre-operational maritime communications satellites based on the OTS/ECS design. Planned for launch in 1980 and 1981.

Meteorological satellite

METEOSAT Europe's first weather satellite. Launched in November 1977.

Scientific satellites

COS-B Launched in August 1975 to study sources of gamma-rays.

ISEE-"B" International Sun Earth Explorer "B" satellite. Launched in October 1977 with its twin satellite, NASA's ISEE "A", to study variations in the Earth's magnetosphere.

GEOS 2 Magnetospheric research satellite launched in July 1978.

EXOSAT Intended to study celestial X-ray sources. Planned for launch in 1981.

SPACE TELESCOPE A joint NASA/ESA programme to place a large high-quality optical telescope in space for use by the international scientific community. Planned for launch in 1983.

Spacelab

A manned laboratory to be carried into orbit by NASA's Space Transportation System. Spacelab's first flight is planned for 1980 and the crew will include the first Western European to orbit the Earth.

Ariane

A launch vehicle for heavy satellites, capable of carrying twice the payload currently carried by the US Delta 3914 launcher. First flight planned for November 1979.

Earthnet

A network of European ground stations for the reception and pre-processing of data received from Earth observation satellites. Earthnet includes the Royal Aircraft Establishment facilities that are used for the reception and processing of data on the oceans from NASA's Landsat Earth resources satellites.

An Unwise Move?

The controversial decision by the Science Research Council to close the Appleton Laboratory and move the scientific staff to the site of the Rutherford Laboratory at Chilton in Oxfordshire has now taken effect. The decision was bitterly opposed by members of the laboratory staff who considered the move a retrograde step and one that could seriously harm the interests of space research in the UK.

The view of the scientific community concerned in radio and space research was summarised in a statement signed by 31 researchers representing 14 universities and three government research establishments (excluding Appleton staff) addressed to the SRC chairman Professor Geoffrey Allen in November.

> *"This gathering of radio and space scientists does not believe that the SRC has produced a convincing case for moving the Appleton Laboratory to Chilton and is concerned that the quality of the services offered to universities and other work carried out by the laboratory will suffer if the move takes place without compelling reasons."*

A letter on behalf of the British Interplanetary Society, addressed to Dr. J. W. King representing staff at Appleton, also expressed the view that the closure of Appleton would represent a severe restriction of U.K. space activity and proffered support in attempts to have the closure decision reversed. Other organisations followed.

Alas, it was all to no avail!

SRC Senior Staff Appointments

On 29 January the Science Research Council announced the following appointments:

"With effect from 1 September 1979 Dr. G. H. Stafford will take up the duties of Director-General of the combined Appleton and Rutherford Laboratories. Dr. G. Manning, Deputy Director of the Rutherford Laboratory, will be appointed as Director of the Rutherford Laboratory for the transition period of five years and will take up his duties on 1 September 1979.

"The Council is actively seeking to appoint a Director of the Appleton Laboratory to take up his duties on the same date, 1 September 1979, on the retirement of Dr. F. Horner."

SRC Central Office Appointments

The following SRC Central Office appointments were confirmed:

Mr. A. J. Egginton is Director responsible for the Science and Engineering Divisions.

Dr. H. H. Atkinson is Director responsible for the Council's Astronomy, Space and Radio and Nuclear Physics Divisions.

Mr. J. J. Beattie is Head of the Science Division.

Mr. J. Hutchinson succeeds Dr. Atkinson as Head of Astronomy, Space and Radio Division.

Major Satellite Contracts for MESH

The largest contract yet for European communications satellites has been signed between the European Space Agency and British Aerospace Dynamics Group, Stevenage, leading the MESH consortium of European companies and payload contractors in West Germany, the United Kingdom and Italy. The total value of these contracts is a healthy £73,000,000.

The satellites will be two ECS (European Communications Satellite) and two MARECS, a maritime derivative of ECS. It is expected that orders for up to three more ECS and a third MARECS will follow.

The Intelsat V Launch Services Contract

The contract which renders official the order for the launching by Ariane of satellites of the Intelsat-V programme was signed on 15 February at the Paris Headquarters of the European Space Agency by Mr. Santiago Astrain, Director-General of Intelsat, and Mr. Georges van Reeth (Director of Administration), representing Mr. Roy Gibson, Director-General of ESA.

Under the terms of this contract the Agency undertakes to provide one Ariane launch with effect from April 1981 and grants an option for a second Ariane launch.

The financial conditions laid down in the contract comprise a firm fixed price of $ US 25.29 million for the first launch and $ US 27.46 million for the optional second launch.

Provision has been made for insurance to cover the possibility of launch failure.

It will be recalled that the Intelsat programme provides for the development and launch of seven satellites, the first four of which are due to be launched by the Atlas/Centaur launcher between the middle of 1979 and the end of 1980. The forecast timetable for the launch of the last three units is as follows:

Unit No. 5 – April 1981.

Unit No. 6 – July 1981 (tentatively planned as the Ariane launch).

Unit No. 7 – July 1982.

The signing of this contract follows the decision taken by the Board of Governors of Intelsat, at its meeting held in Washington from 7 to 14 December 1978, to order an Ariane launch for its Intelsat V telecommunications programme.

ESA Delegation's Visit to China

At the invitation of the Chinese Electronics Society, an 11-man delegation from the European Space Agency (ESA) visited China from 12 to 19 February 1979. The delegation, which was headed by ESA's Director General, consisted of representatives of five of ESA's 11 Member States and six staff members of the Agency.

The ESA delegation had detailed discussions with the Chinese Electronics Society, the Chinese Astronautics Society and the Chinese Academy of Science, and visited space institutions in Peking, Shanghai and Nanking. On 18 February, the delegation had the honour of being received by Vice Premier Wang Cheng.

Details were exchanged of current and future space programmes, and the possibilities for cooperation in a number of fields of mutual interest were identified. It was agreed to intensify contacts during the coming months, in order, after consultation with the relevant authorities, to define precisely how best this cooperation can be organised.

NEXT MONTH

A number of scientific space programmes planned for the 1980's by the National Aeronautics and Space Administration will be in danger of cancellation if curbs being placed on the space budget by the Carter Administration are not lifted. In a major review article, Dr. David Baker sifts the evidence. Gordon L. Harris tells the inside story of NASA's Public Relations over the past 20 years. Gordon R. Hooper completes his major feature 'Missions to Salyut 6,' and Nicholas L. Johnson considers the Military and Civilian roles of the Salyut space stations.

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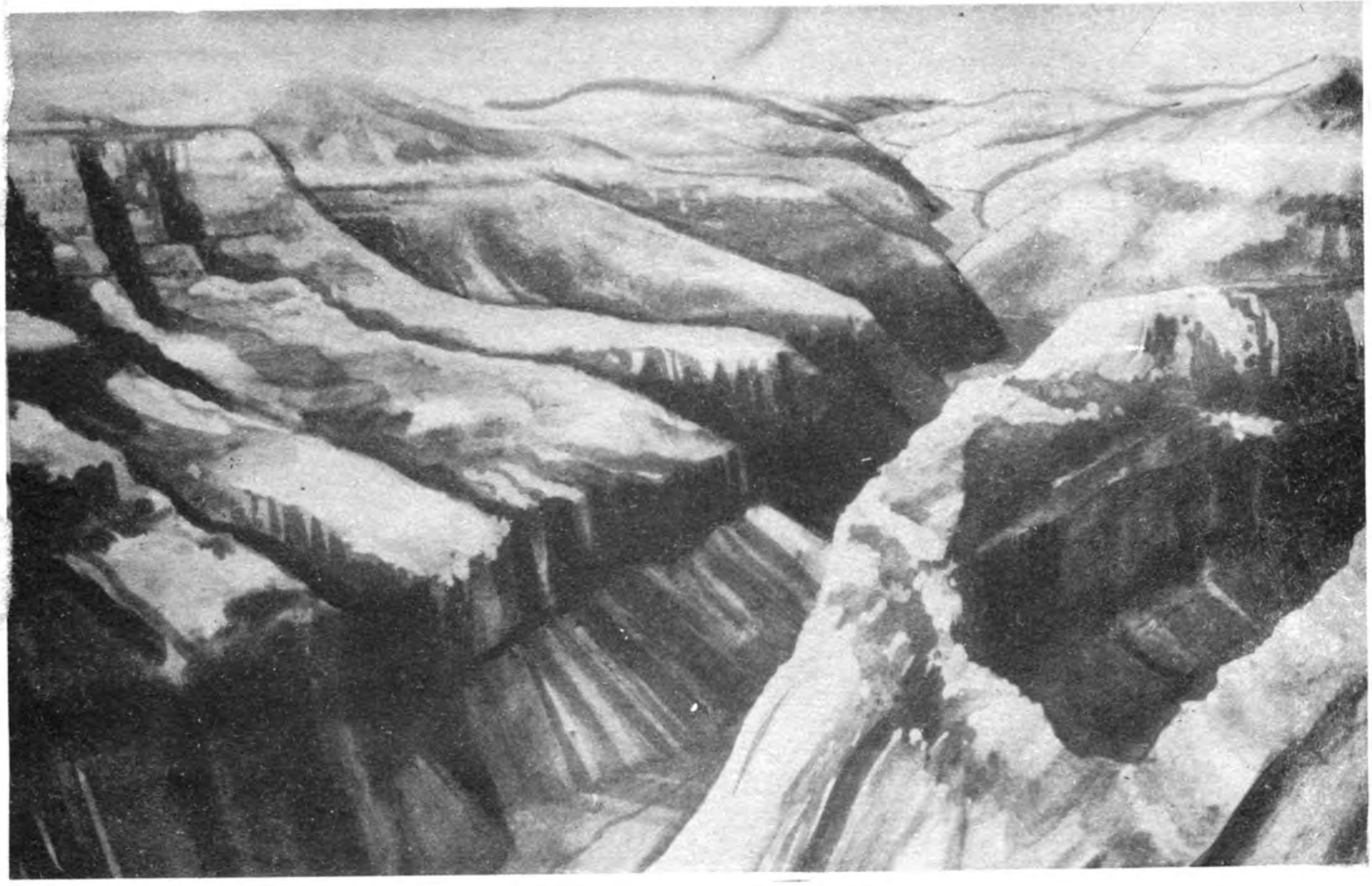
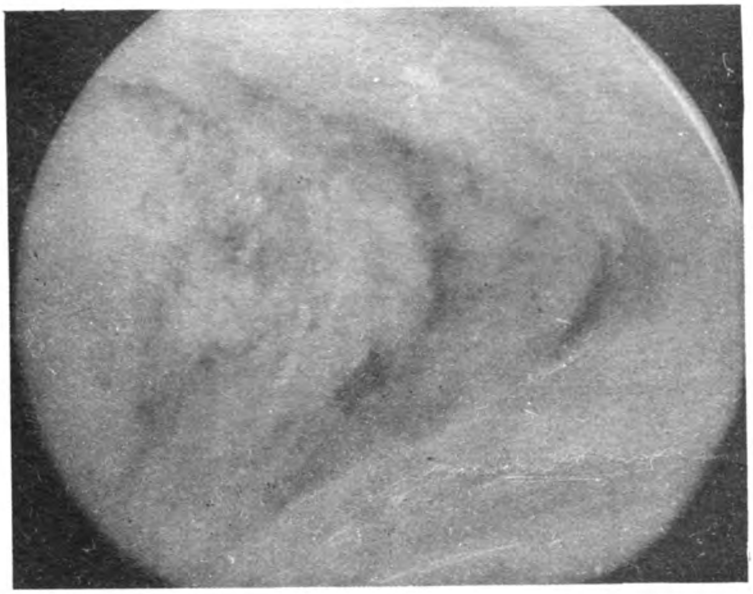
SPACEFLIGHT





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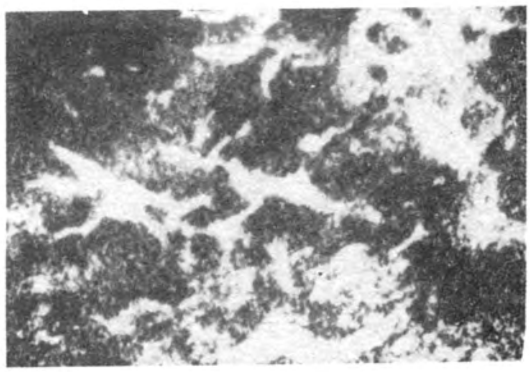

BIS DEVELOPMENT PROGRAMME

PROGRESS REPORT NO. 11

An abrupt departure from the cosv atmosphere of 12 Bessborough Gardens and unceremoneous deposit in the strange surroundings of 27/29 South Lambeth Road made one feel rather like a hermit crab, ripped out of one shell and put into another and, therefore,feeling very cold and exposed!

Nothing was the same. The old familiar scenes had gone. Whereas, before, one could merely turn on one's heel to find the appropriate files and papers, they were now scattered, mixed, or – perish the thought – irretrievably lost. Things which had previously been to hand now required concentration to try to recall where they might be, and so, for some days, one had to wander from office to office, picking up things here and depositing them there but, overall, feeling like one of the lost tribes in *Exodus.*

Settling down was not helped by the slow delivery of much-needed equipment, right down even to the front door, which had no knocker because this had been taken off to enable it to be painted, and re-painted. Eventually, the door knocker found its proper resting place, Eric Waine graced the area above with the magic numbers "27" and "29", the temporary phone was converted to a permanent one, with extensions,and a "Entryphone" completed the accoutrements.

Inside, however, things initially became worse with the deposit of boxes and crates which had hitherto lain the Outposts of Empire. Forty-five large packages, containing our stocks of Daedalus, alone, filled up the front hall the moment it had been cleared, followed by packages containing *JBIS, Spaceflight,* boxes of "T" shirts – until we eventually wondered where we could possibly put it all.

However, weekend stints began to bring about improvements. Rooms were re-arranged, a rudimentary work-flow production line established, missing items retrieved and slowly, order came forth from chaos.

Andy Wilson screwed on the signs to identify the male and female toilets, which eased yet another problem, before disappearing into the basement, which had been left in one infernal mess, to strip walls, ceiling, and generally clear up. In the meantime, Phil Freshwater was busy taking up the lino from 12 Bessborough Gardens, in readiness for re-laying it in the basement and, eventually, improving that part of our facilities too.

A bitter war raged with the central heating system. Curious discoveries were made. For example, some radiators showed no inclination to be part of the heating system at all, others were highly temperamental and – more excitingly – a radiator in one of the loos simply glowed with radiant heat, making it the warmest place in the building, and hence the vexed question of ownership only resolved finally when Andy put up the "Ladies" sign.

The reception area, meanwhile, had been carpeted, the only place in the building to be so honoured. For weeks afterwards this attracted every workman in sight like a magnet. No matter for what purpose the workmen had nominally appeared,e.g. if even to put some bricks on an outer wall, the most vital part of their task consisted of carefully wiping their boots in the nearest pool of wet concrete and heading purposefully towards that carpet. It was the same with deliverymen. They ignored the reception office and the staff on the left and headed straight for the carpet on the right, preferring to shout across than miss that memorable experience. There was no way of stopping them. The staff were outgunned, outmanned and outmanoeuvred. They simply hadn't got the matching speed and stamina.

Visitations from officials also continued unabated, on one occasion so many arriving in relay that they took up the whole of the working day of both Assistant Secretary and Executive Secretary. Many were, incidentally, rather piqued to find that they now had to wait outside the front door for admittance, instead of marching straight through as though they owned the place.

The Planning Officer, on arrival, was greeted with cries of "Number 21" – he being the twenty-first official with a grandiloquent title and matching powers, though we suspect that there was also a number 22 who came and went rather surreptitiously. We also missed the Drainage Officer, too. It is not fair to list him as "Number 23". His work was done early in the proceedings so perhaps he ought to have been "Number 4B". Additionally, we tended to miss those who did not seek entry but who were content to weigh and measure from the outside, i.e. mainly to "case the joint", so to speak.

Eventually, the Builders arrived to mend the front door, which had meanwhile jammed, and to erect large gates for the rear. These were most impressive. Unfortunately, they had no locks or bars or key or any way of securing them, nor had any provision been made for fixing them to stone pillars! From a security point of view they were far inferior to temporary wooden hoarding which had previously blocked the gap! They represented most curious constructions. Should they be dug up eons hence, future archaeologists will have a hard time trying to decide what they were for. Even experts of our own time would be unlikely to attribute them as being gates.

BIS DEVELOPMENT PROGRAMME

SECURING NEW MEMBERS

AN APPEAL FROM THE MEMBERSHIP AND PUBLIC RELATIONS COMMITTEES

The Society relies on the continued introduction of new members to support its growth and to further its Development Plans. Both depend heavily on the goodwill of existing members, for long experience has shown that there is no better nor more effective method of promotion. Some members are able to introduce new recruits directly, particularly if they, themselves, are active in the space field and so frequently meet many others with similar interests. Details of the Society will be sent at once to friends or colleagues on request: simply send us their names and addresses. Similarly, if you have a chance of mounting a small display, copies of back issues of *Spaceflight* will also be made available for this purpose.

The Public Relations Committee believes that every member should be involved in its work. There are endless opportunities to participate. References to the Society, particularly if its address can be included, in House and other journals, in letters to magazines, articles, books (not forgetting the inclusion of the name of the Society in the index!) either by the member concerned or even by friends or colleagues, can be invaluable. Promoting public relations in space is not the work of a few but the concern of every member.

T 1

SPACEFLIGHT

A Publication of The British Interplanetary Society

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Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

CONTENTS

VENUS RIFT VALLEY. An artist's impression of Venus's newly discovered rift valley, over 5km deep, 280k wide, at least 1,400km long and which is larger than *Valles Marineris*, previously the largest known canyon in the Solar System. Measurements were made by the radar mapping instrument on Pioneer Venus Orbiter. *Below left*, this first full-disc picture of Venus was taken by Orbiter on 19 Feb. 1979. It shows a turbulent, cloudy atmosphere with bright cloud areas wrapping around both polar regions. East-West rotation (right to left) is apparent in the clouds which obscure the surface and move round the planet at a velocity of about 100 metres per second. The mottled, small features near the centre seem to be convective cells caused by atmospheric heating due to solar radiation. *Right*, radar image of an area south of the feature 'Alpha' at a resolution of about 16km. A 320km diameter crater with a priminent central feature appears upper right. *NASA*

Owing to the trade agreement giving employees of the printing industry four weeks annual holiday, this is a combined issue covering the months of August and September. The October issue of *Spaceflight* will be published during the third week of September, as usual.

MILESTONES

April

30 British Interplanetary Society transfers administration to new Headquarters Building at 27-29 South Lambeth Road, London, SW8 1SZ. This move, made possible by the generous response of members and friends of the Society to the Development Appeal over the past five years – and achieved in the face of many difficulties, not least inflation in building costs – marks a significant development for the Society.

May

1 Space Shuttle orbiter 'Enterprise', mated with External Tank and Solid Rocket Boosters, is moved by 'giant crawler' from Vehicle Assembly Building to Launch Complex 39A at Kennedy Space Center. 'Enterprise', which will not fly into orbit, is being used for compatibilit checks with pad and gantry prior to roll-out of first flight vehicle 'Columbia' later this year.

8 Space Department, RAE, predicts that Skylab 1 will decay from orbit about 5 July.

11 Orbital Test Satellite (OTS) 2 completes first year in space. OTS is the pre-operational communications satellite in Clarke (geo-stationary) orbit being used to prove the design and system engineering embodied in the European Communications Satellite (ECS), the first of which is expected to be launched in 1981. British Aerospace Dynamics Group was prime contractor leading the MESH consortium which built OTS for the European Space Agency.

11 Reported from Washington that preparations for launch of first Space Shuttle at KSC have fallen six weeks behind schedule mainly because of delays in fitment of thermal tiling and test instrumentation, crew training and in Space Shuttle Main Engine testing (now picking up). First launch of 'Columbia' now expected "first quarter of 1980."

13 Soviets launch automatic cargo craft Progress 6 from Tyuratam at 0717 hrs (Moscow time) with 2.5 tonnes payload including fuel, food, water, scientific equipment and mail.

14 NORAD predicts that Skylab will re-enter the atmosphere between 17 June and 2 July if further in-flight manoeuvres cannot be made.

15 Progress 6 docks with Salyut 6 and resident cosmonauts Vladimir Lyakhov and Valeri Ryumin prepare to transfer supplies and fuel. Link-up took place at 0919 hrs (Moscow time).

BIS DEVELOPMENT PROGRAMME

CUTAWAY DRAWINGS

To improve our technical coverage of major space developments, we are inviting the cooperation of artists having the ability to produce cutaway drawings to a professional standard. Examples of subjects we wish to illustrate are the Soviet spacecraft Salyut, Soyuz and Progress, the NASA Space Shuttle, and various scientific and applications satellites. Full acknowledgement will be given to the artist responsible for any particular work. If you can help, please write to: Mr L J Carter, Executive Secretary, British Interplanetary Society, 27-29 South Lambeth Road, London SW8 1SZ.

В журнале не печатается ряд страниц.

FIRST MEN ON THE MOON

10TH ANNIVERSARY LETTER TO THE SOCIETY FROM APOLLO 11 COMMAND MODULE PILOT MICHAEL COLLINS

SMITHSONIAN INSTITUTION

Washington, D.C. 20560
U.S.A.

July 20, 1979

A Greeting to All B.I.S. Members

On the occasion of the 10th Anniversary of the flight of Apollo 11 it gives me great pleasure to send my warm greetings to Society Members.

Since its founding in 1933, your Society has steadfastly held to its aim of manned interplanetary flight. In your pre-War studies of lunar spacecraft were embodied many design concepts which eventually were used to take us to the Moon. I am sure that most of these enthusiasts never expected to see their project realized within their lifetime.

After the Apollo 11 Mission we crew members visited a lot of cities. One of them was, of course, London. The gold medals we received from the B.I.S. were most appreciated and were accepted on behalf of the many thousands of people who made the superb spacecraft and our mission so successful.

I note that the Society has not slowed in its aims toward advancing future concepts of space flight. I have seen the report on Project Daedalus—a most ambitious undertaking! And yet, I wonder if this imaginative concept of stellar flight is much more ambitious than studies by the Society Members forty years ago.

Congratulations on your continued educational and inspirational efforts!

Sincerely,

Michael Collins
Under Secretary

THE NASA BUDGET - FISCAL YEARS 1979-80

By David Baker

Owing to the tight fiscal constraints being placed on the National Aeronautics and Space Administration by the Carter Administration, many important objectives in space science and technology planned for the 1980's will be seriously frustrated. Trying to unravel the implications of recent budgets and their likely impact on future projects is a major task. More money is required to see the Space Shuttle over development hurdles and this will have its own impact on the budgetary format. We believe this report is unique – there appears to be no similar analysis available in the United States – and the author has asked us to point out that the tables which contain the basis for his arguments were compiled from Presidential Executive sources and that any errors are entirely his own. We shall welcome discussion of the conclusions from any quarter. Ed.

PRESIDENT JIMMY CARTER visits the Kennedy Space Center on 1 October 1978. But does his Administration really comprehend the implications of current belt-tightening policies on the major opportunities for scientific and technological advance that will be opened up in the Shuttle era? *Left to right,* the President, Mrs. Carter and daughter Amy are shown a model of the Shuttle by Dr. Robert A. Frosh, NASA Administrator. Between the President and Dr. Frosh is NASA Deputy Administrator, Dr. Alan M. Lovelace.

National Aeronautics and Space Administration

Introduction

This year sees the 10th anniversary of what many regard as the most significant accomplishment of the U.S. space programme: the first manned landing on the Moon in July, 1969. It is also just a decade since the then President Richard M. Nixon set up a space task group to prepare a "definitive recommendation on the direction which the U.S. space programme should take in the post-Apollo period." Composed of the Vice President, the Secretary of Defence, the NASA Administrator and the Presidential Science Advisor, it submitted its findings in September, 1969, and provided a clear indication that the U.S. should pursue "the basic goal of a balanced manned and unmanned space programme for the benefit of all mankind." The report outlined a basic inventory of programme goals against which it set three separate funding profiles from low to high in order of increasing commitment.

The lowest funding level envisaged a Space Station and Shuttle operational by 1977, an Out-of-Ecliptic (OOE) survey of the Solar System by 1978, availability of the Nuclear Shuttle, Space Tug and a Lunar Orbit Station by 1981 and a base on the Moon in 1983; by 1986, Man would be on Mars. With the exception of the Shuttle and OOE goals, none of these have a viable chance of emerging for at least the next decade. When President Nixon received the report his administration was preparing the Fiscal Year (FY) 1971 budget. It is significant that from that date NASA was unable to secure funds for programme growth. By 1972 the Space Task Group report had been shelved as an academic exercise in what might have been but wasn't and hopes for a manned Moon and planet goal were dashed.

Last year, President Carter presented *his* report on the future goals of the U.S. space programme. It endorsed a suspicion that NASA had become a political pawn ripe for "rationalization," with belt-tightening policies to the fore. While sweeping generalizations about funding levels and budget profiles are nearly always inaccurate – the real significance of fiscal policy only emerges from the most abject scrutiny – this report will, nevertheless, attempt to point out significant aspects of current budget levels.

Since FY 1959, the U.S. federal budget has included funds for NASA and a survey of the 22 annual budgets to FY 1980 shows a revealing trend. By FY 1965 the civilian space budget, allocated primarily to NASA but also in small amounts to other government agencies, had reached a peak to which it would never return. From FY 1966 civilian space funds failed to keep pace with inflation. In dollar amounts the allocation fell by 1.8% in 1966, 3.8% in 1967, 8.8% in 1968 and 14.4% in 1969. But, to make these figures worse, federal inflation went from 5.1% in 1966 to 3.2% in 1967, 4.7% in 1968 and 4.4% in 1969. Not only did the dollar amount fall, the dollar equivalent would have had to show a reverse trend just to keep pace with inflation. All this is history and the consequences well known to *Spaceflight* readers. It does help to show where the rot set in, however, and Table 1 provides a year by year comparison of the civilian space budget set against levels of inflation. It also provides a column of annual percentage increase in federal outlays to show how the programme continues to be a decreasing part of the U.S. budget. Another column relates all three to the annual percentage increase in gross national product to show how civilian space endeavours fail to keep pace with national wealth.

The product of Table 1 is a recognition of governmental apathy toward new technology, because while money alone is a poor index to national capability the use of federal funds for space R&D has always shown a high return in direct and indirect assets. The Carter administration shows an appalling lack of foresight and fails to recognize the need for national goals and stimulation for the next generation of scientists and engineers. While satisfying short term goals, the NASA programme falls short of its potential because there is no long term plan, or strategy, by which to measure the validity of specific projects. This can be seen to good

Table 1: Federal funding trends

Year	Annual % change in civilian space budget	Annual U.S. inflation (%)	Increase in federal outlays (%)	Annual increase in GNP (%)
1960	+71.0	0.2	0.12	5.09
1961	+96.9	1.8	6.04	2.21
1962	+100.8	1.9	9.22	7.59
1963	+94.6	2.7	4.21	5.37
1964	+34.7	2.5	6.53	6.92
1965	+2.8	2.2	-0.13	6.64
1966	-1.8	5.1	13.7	9.74
1967	-3.8	3.2	17.53	7.39
1968	-8.8	4.7	12.59	7.16
1969	-14.4	4.4	3.19	8.89
1970	-7.6	7.2	6.52	6.12
1971	-11.8	7.3	7.55	6.29
1972	-1.9	7.3	9.74	8.95
1973	+1.1	6.6	6.49	11.43
1974	-10.2	7.9	9.12	9.83
1975	+5.1	12.5	20.94	7.02
1976	+10.4	12.0	12.13	11.74
1977	+7.0	9.9	9.91	13.08
1978*	+5.6	7.3	15.01	11.15
1979*	+5.9	7.8	8.21	11.32
1980*	+2.9	7.0	7.7	9.45

* Figures for these years are estimates.
The above table shows annual changes in the civilian space budget set against inflation with the annual change in federal outlays and GNP (Gross National Product). For instance, in 1968, the civilian space budget went down by 8.8% compared with 1967 while total government projects went up by 12.59% and GNP by 7.16%. The civilian space budget category includes non-NASA funds and shows that since 1966 money has failed to keep pace with inflation.

effect in the planetary programme where missions are approved only if there is a financial wedge made vacant by an expiring project. Little credence is given by the administration to scientific needs or coherence of inter-relationship with missions already approved. In this way NASA is made the instrument of federal manipulation rather than the non-partisan caretaker of U.S. space research it was set up to be.

Fiscal Year 1979

Analysis of NASA space funds, excluding an amount for aeronautical research and technology, must take account of the total spending on federal space projects. In FY 1979, NASA space money accounted for about 52.1% of all U.S. space funding; Defence Department got 45.6% and the rest was shared among other government agencies. It is all too easy to believe that NASA takes the lion's share of space money. It does have the majority share but as the trend in Table 2 indicates that position will be usurped by the early 1980's. Moreover, civilian programmes are consistently failing to keep pace with the deflator applied to fiscal budgets. Table 2 shows that whereas the total money for all space projects has exceeded the inflation rate for the past three years, civilian space money has been falling since 1966. This is because Defence Department allocations have increased from 24.2% of the total to the current 45.6% in the same period. It is outside the scope of this report to delve into military space operations. Suffice it to say that such operations are really only just beginning and the developments anticipated for the next decade will completely overturn the current situation where NASA holds majority share.

The FY 1979 NASA space budget was placed before Congress early last year with a request for $4,107.5 million, up 7.1% on FY 1978. In passing through the House of Representatives, the Committee on Science and Technology added $15.5 million at the end of minor adjustments. The most significant move was to increase the space applications category by $14 million and delete funds for modifications to the Goddard Space Flight Centre. Also, $4 million was added for Orbiter production but more about that later. For its part, the Senate Committee on Commerce, Science and Transportation returned the applications and building categories to the original request, adding an extra sum for life sciences, space research and technology, and energy programmes. Senate Committee action increased the original NASA request by $17 million. At the end of the day, the Conference Committee voted in a $4,126.5 million budget, up $11 million on the original request.

The FY 1979 budget was Carter's second attempt at reducing the massive federal deficit between income and expenditure; his first was the FY 1978 budget revision to ex-President Ford's original submission in January, 1977. Ford's original FY 1978 budget envisaged a deficit of $46,950 million on expenditures totalling $439,967 million; Carter's revision increased this to $57,749 million on expenditures of $459,373 million. At last accounting, the FY 1978 budget incurred an actual deficit of $48,839 million on expenditures of $450,836 million. Fiscal Year 1979 provided a $500,174 million expenditure plan with a $60,586 million deficit. The long term forecast based on legislation pending in the FY 1979 budget and enactment of White House fiscal policy envisaged a deficit of $37,500 million in FY 1980 and an increasing surplus from FY 1981. The federal account has been in surplus for only 2 of the 22 budget years since 1959 and continually in deficit

Table 2:

Year	NASA % share of total space money	DOD % share of total space money	Annual % change in total space money: Total	Civilian	Inflation (%)	Total space budget as % of federal outlay
1959	33.25	62.38				0.85
1960	43.30	52.62	+35.8	+71.0	0.2	1.15
1961	51.21	45.01	+69.6	+96.9	1.8	1.85
1962	54.53	39.40	+82.2	+100.8	1.9	3.08
1963	66.72	28.51	+64.9	+94.6	2.7	4.88
1964	73.43	23.41	+25.7	+34.7	2.5	5.78
1965	73.86	22.62	+1.8	+2.8	2.2	5.89
1966	72.66	24.23	+0.2	-1.8	5.1	5.19
1967	71.65	24.68	-3.3	-3.8	3.2	4.26
1968	67.62	29.33	-2.8	-8.8	4.7	3.66
1969	63.96	33.68	-8.8	-14.4	4.4	3.23
1970	66.42	31.42	-10.6	-7.6	7.2	2.72
1971	65.41	31.89	-11.2	-11.8	7.3	2.24
1972	67.13	30.75	-3.5	-1.9	7.3	1.97
1973	64.11	33.63	+5.5	+1.1	6.6	1.95
1974	59.44	38.05	-3.8	-10.2	7.9	1.72
1975	59.32	38.51	+5.9	+5.1	12.5	1.51
1976	60.63	37.28	+8.2	+10.4	12.0	1.45
1977	57.50	40.31	+12.5	+7.0	9.9	1.48
1978*	55.86	41.86	+8.4	+5.6	7.3	1.44
1979*	52.12	45.63	+13.7	+5.9	7.8	1.49

* Estimates

The above table shows NASA and DOD percentage shares of the total space budget, the percentage change to the total, the percentage change to the civilian portion of that total (which includes non-NASA civilian allocations), the annual US inflation rate and the total space budget as a portion of total federal outlays by year. For instance, in 1979 the US will spend 1.49% of its federal budget on space of which 52.12% will go to NASA and 45.63% to the DOD. The balance is allocated to other government space projects. The total 1979 space budget (NASA and DOD) is up 13.7% which, set against the inflation rate of 7.8%, could be thought of as a rise. However, the civilian portion (NASA *and* other government non-DOD space projects) goes up by only 5.9%, considerably below that required to provide an increase. Similar historical detail can be obtained by reading across for any year in question.

since 1970. However, it should be remembered that in Fy 1977, the Ford budget projected a deficit of $22,800 million for FY 1978 and a surplus of nearly $10,000 million for 1979: Projections continue to fall far short of actual conditions; the FY 1979 deficit is now estimated at $37,379 million.

It will be seen from the above figures that the FY 1979 deficit increased from an estimated surplus of $10,000 million to an estimated deficit of $37,379 million in the two years up to the beginning of FY 1979. This turnaround was partly due to the change in Presidential administration and amendments to the budget. Against this background, NASA money for FY 1979 represented a compromise between agency needs and fiscal policy. A healthy $32.1 million was provided for new projects–so-called "new start" money–including an Out-of-Ecliptic mission in 1983, and Earth radiation and solar mesospheric explorers for 1981. More astonishing because of optimistic noises toward space projects from the Carter administration was a denial of funds for a fifth Shuttle Orbiter, a follow-on the the Viking Mars project and timely development of the Halley comet fly-by mission.

In the FY 1978 amendment, the Carter administration injected funds for a Mars sample-return mission study plan but the resulting reversal was typical of the change between Fiscal Years 1978 and 1979 where the new President gradually became aware of important aspects of White House administration and learned of the need to woo Congress rather than bludgeon it into agreement. If pressure is not soon brought to bear on the negative attitudes toward space science and technology, NASA will be unable to secure the returns that should accrue from an investment of this magnitude. The Shuttle is an example of how bad the situation has become; unable to use it as designed, NASA will probably not now have the ability to exploit the Shuttle for new initiatives in the civil use of space operations. To fully utilise the dramatic new capabilities provided by this reusable transporter, NASA needs an inventory of accessories from which to service the needs of the user market.

In this regard, the civilian space agency could be thought of as a hire service for launching, processing and tending other people's satellites and payloads, providing complex and difficult space operations to satisfy the most demanding customer requirements; it could also be said to generate a limited amount of in-house R & D, develop scientific satellites for the US government and aid the President in demonstrating national potential. This cynical view, brought on by the recent interference at White House level, is brought about in the first instance by an impending transformation in the NASA role. If the policies of the Carter administration are allowed to cut short the technology and the systems operation essential to maximising the Shuttle, NASA will be irrevocably committed to a third rate position. The next five years are the most critical for the US space programme and stagnation now will suppress benefits and advantages so close to realisation.

Shuttle Funds

Shuttle funding profiles reflect the technical difficulties experienced as the project nears fruition but it is necessary to dig deep between the fiscal lines for root causes. The adverse trend really began in FY 1976 for which in late 1974 the agency obtained authority from the Ford administration to request $1,206 million for Shuttle R & D (Table 3). Inflation in SSME and ET development (by 3.9% and 24.4% respectively) was offset by Orbiter, SRB and Launch and Landing category reductions (of 1.1%, 13.8% and 1.9% respectively). Excluding the Launch and Landing (L & L) category, which really does not belong with technical R & D work, a planned budget outlay of $1,155.1 million increased by $975,000 (0.08%).

Table 3: FY 1976 Shuttle funding history

	Original plan ($xmillion)	Final total ($xmillion)
Orbiter R & D	877.3	867.335
SSME	135.5	140.8
SRB	76.2	65.7
ET	66.1	82.24
Launch & Landing (L & L)	50.9	49.925
Totals	1,206.0	1,206.0

Note: throughout all tables, SSME is Space Shuttle Main Engine, SRB is Solid Rocket Booster, and ET is External Tank.

The FY 1976 budget period was the last in which the financial year began annually on 1 July. From FY 1977 the budget year would begin 1 October, with a so-called Transition Quarter (TQ) between June 30 and October 1, 1976. Excluding the L & L category, TQ Shuttle funding was planned at $300 million but came out 0.2% up at $300.6 million (Table 4). The total Shuttle R & D category appeared to balance because during that period NASA reduced the L & L section by 2.8% to avoid exceeding the $321 million allocated. In the 15 month period between 1 July, 1975, and 30 September, 1976, NASA had offset increasing cost demands by taking a total $1.575 million from the L & L category, decreased by 1.9% and then 2.8% in the FY 1976 and TQ budgets, respectively. Theoretically, this was the time when NASA should have gone before Congress–perhaps in the spring of 1977 when management appeared on Congressional budget committees to discuss the FY 1978 request. The Committees had specifically requested testimony on any financial problems, especially with the Shuttle, so that they could do their best to obtain for NASA money essential to prime goals. The fact that NASA failed here was primarily because no one really foresaw the expensive technical problems that would emerge between 1977 and late 1978. Where in FY 1976 and the TQ L & L money had been the buffer for costly technical solutions to engineering problems, financial crises over the next three years would move beyond the capacity of this category to absorb the excess demand.

Table 4: Transition Quarter Shuttle funding history

	Original plan ($xmillion)	Final total ($xmillion)
Orbiter R & D	230.9	216.3
SSME	36.0	37.9
SRB	18.0	20.4
ET	15.1	26.0
Launch & Landing (L & L)	21.0	20.4
Totals	321.0	321.0

The original FY 1977 request of $1,288.1 million for Shuttle R & D comprised of $1,182.9 million for Shuttle elements and $105.2 million for L & L (Table 5). This request was put through during the first half of 1976 and the fiscal period came into effect on 1 October of that year. Technical problems during the 1977 calendar period produced the following effect. The Orbiter, SRB and ET portions went up by 6.7%, 21.5% and 32.2% respectively, cost overruns totalling $94.7 million partially offset by an $11.6 million (6%) reduction in SSM money and $28.1 million (26.7%) in L & L funds. The net effect was to increase Shuttle R & D money (excluding L & L) by 7% from $1,182.9 million to $1,266 million.

Table 5: FY 1977 Shuttle funding history

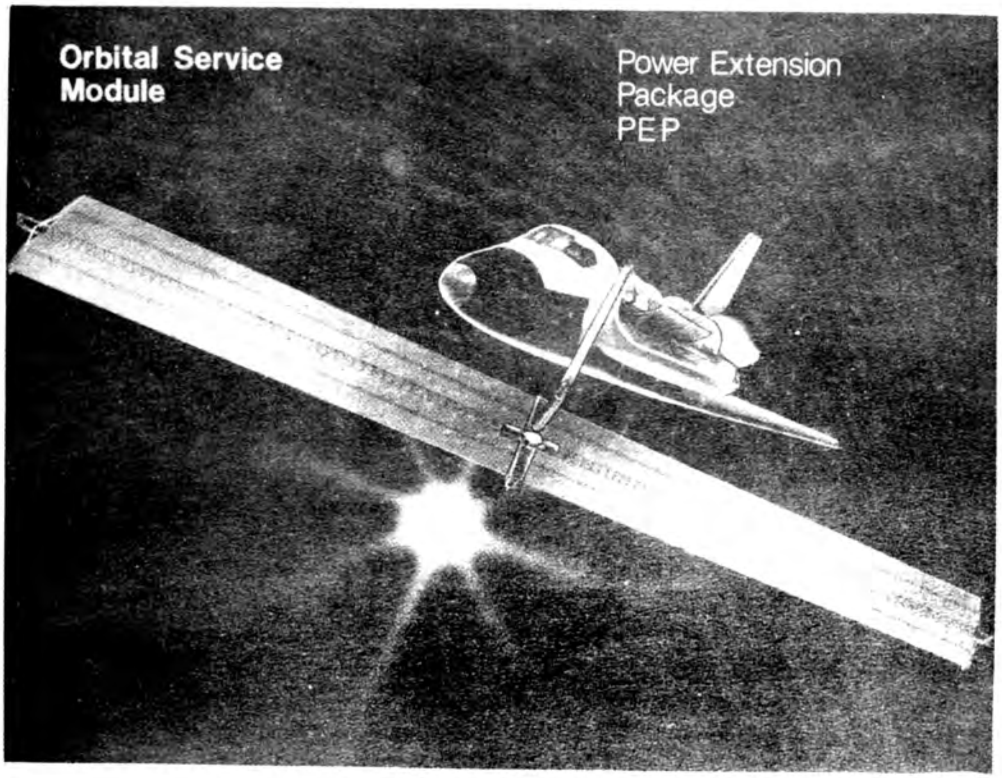
	Original plan ($xmillion)	Final total ($xmillion)
Orbiter R & D	842.5	899.4
SSME	193.8	182.2
SRB	82.6	100.4
ET	64.0	84.0
Launch & Landing (L & L)	105.2	77.1
Totals	*1,288.1*	*1,343.1*
Production supplement retrospectively allocated		70.0
Total		*1,413.1*

By now the cost problem was beyond containment. The L & L category was incapable of absorbing the escalating increases and the accounted total of Shuttle R & D was inflating beyond the levels approved by Congress. Mention should here be made of a $70 million supplement appended to the FY 1977 budget as a result of amendments to the FY 1978 budget after enactment. This money was for production and as such is not a reflection of Shuttle funding trends influenced by technical problems. It will be excluded from percentage change evaluation but it is found in the accompanying tables for the record.

In FY 1978 NASA continued its policy of borrowing from categories not unduly critical to the development programme. That it was able to do so came as a result of the new Orbiter production category. For this $141.7 million was required to continue long-lead item procurement, a policy begun by a FY 1978 amendment from the Senate that gave NASA an additional $95 million for FY 1977. It was intended that the $95 million would be an advance on the $141.7 million production allocation in FY 1978. As it turned out, the Conference Committee endorsed a recommended $5 million increase in FY 1978 production money and $100 million was advanced for spending in FY 1977. In its language for the Committee report, Senate conferees ordered the money to be assigned "primarily to Orbiter production *and to a lesser extent to Shuttle design, development, test and evaluation (D.D.T. & E.) activities if necessary*" (author's italics). It will be seen from the summary of FY 1977 Shuttle funds that 70% of this was spent on production procurement with 30% set against escalating development costs. Thus, NASA was able to get an advance for Orbiter production and use $30 million to defray cost increases.

As displayed in Table 6, FY 1978 production money was the balance between $141.7 million allocated and $100 million advanced to the preceding fiscal year. Total Shuttle money for FY 1978 was approved at $1,354.2 million, composed of $1,079 million for R & D, $141.7 million

SPACE SHUTTLE ORBITER SOLAR ARRAY. A 1978 study on Space Shuttle energy support has produced this artist's concept of the Orbiter Solar Array System (OSAS), a solar panel to receive the Sun's rays and possibly add 22 days' life to a Shuttle mission. Total system weight would be 900 kg producing a total output of 29 kW of electrical power, reducing the amount of liquid oxygen and liquid hydrogen needed to run fuel cells.



National Aeronautics and Space Administration

EXTRA BOOST. The strap-on boosters proposed for raising Space Shuttle payload to high inclination orbits are seen in this model. Attached to the back end of the Solid Rocket Boosters (SRB's) they are non-recoverable.

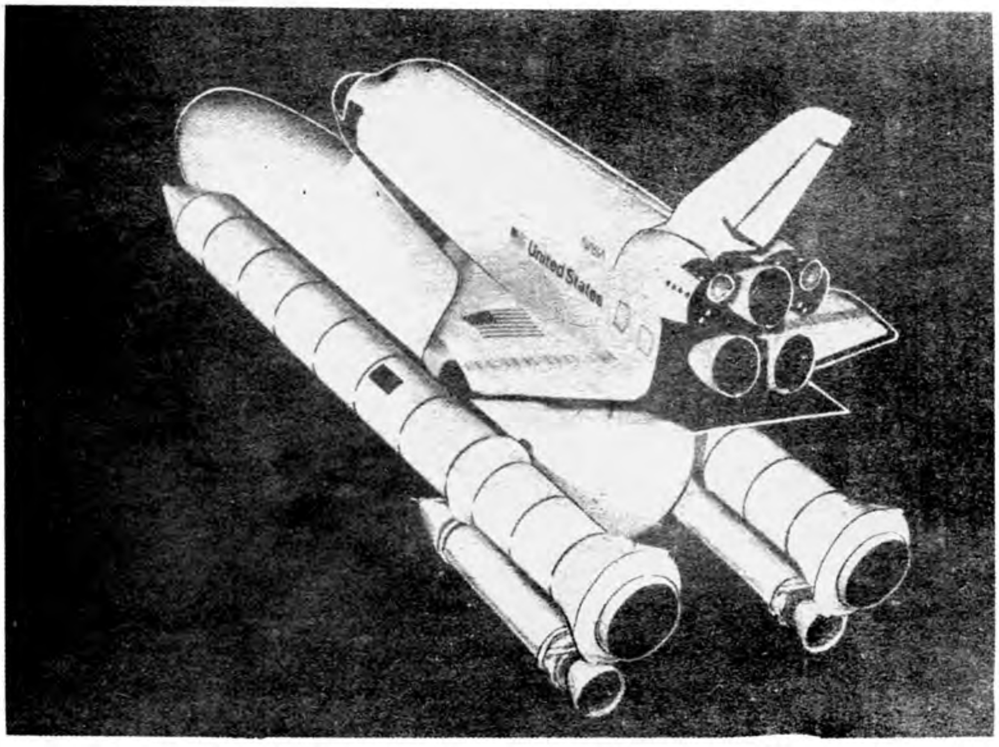


Table 6: FY 1978 Shuttle funding history

	Original plan ($xmillion)	Final total ($xmillion)
Orbiter	695.5	813.06
SSME	219.9	197.4
SRB	83.6	104.998
ET	80.0	88.03
Launch & Landing (L & L)	133.5	104.012
Production	141.7	41.7
Totals:	*1,354.2*	*1,349.2*

for production and $133.5 million for Launch and Landing. Retaining the premise that only R & D funds are a reflection of funding trends in development cost, analysis of the $1,079 million is pertinent to this review. Orbiter costs rose by $117.56 million (16.9%), SRB expenses went up by nearly $21.4 million (25.6%) and ET development increased by $8 million (10%).

During the period covered by FY 1978 (October 1977 to September 1978), NASA ran into problems with Orbiter weight growth and thermal insulation development. Main engine (SSME) development was largely on track and good progress enabled a fiscal decrease of $22.5 million (10.2%). By the end of the year, the $1,079 million R & D portion of NASA's overall Shuttle budget had gone up by nearly $124.5 million to $1,203.488 million. This represented a Shuttle R & D increase over the original budget request estimate of 11.5%. Some of the overrun was absorbed by a $29.5 million reduction in L & L–the favourite escape clause–and all the rest by the $100 million backed up to FY 1977. On paper, the $1,354.2 million Shuttle plan showed a promising projection compared with the $1,349.2 million actually spent. Had it not been for a $100 million "transfer".

Between FY 1976 and FY 1978, including the Transition Quarter, Shuttle R & D activities went up by $205.6 million over a projected outlay of $3,717 million for the four budget periods. This was an increase of 5.53%; or 0.08%, 0.2%, 7% and 11.5% for each of the four periods respectively. FY 1978 is the last year for which fiscal accounting figures are available, but estimates for FY 1979 are possible. The FY 1979 request, made up during the closing months of 1977, included $1,439.3 million for the Shuttle: $857.2 million on R & D, $454 million on Orbiter production and $128.1 million on Launch & Landing. It was to be a revealing submission for the following reasons.

FY 1978, the revision provided by the incoming President Jimmy Carter, was different in several respects to later submissions. Overall, the FY 1978 request reflected a degree of naivete on the part of the new administration; anxious to be seen moving rapidly on campaign issues, the defence budget request went down by $2,800 million and social services funding went up. NASA got a modest shot in the arm with money for Mars exploration studies but that didn't last a year before a post-Viking study plan was thrown out by the White House. There was no change in the FY 1978 Shuttle request but the Carter administration revealed its policy a year later when the FY 1979 budget was released. It contained no money for a fifth Shuttle Orbiter, a modest start on which should have been made in that year, and drastic cuts from a fund supporting space construction concepts. The latter was seen by the administration to be capable of generating a major programme that could, in the early 1980s, recruit support from Congress and demand high funding profiles.

Major policies in the Carter administration are being influenced by budget considerations to the exclusion of reasonable needs or expedient developments. The decision to reduce the planned Shuttle fleet from 5 to 4 Orbiters was another cost cutting move that if left unchallenged would have resulted in depleted capability. But before looking at the argument for a fifth Orbiter, the FY 1979 R & D budget provides the final example in the observed run of cost escalations. Within the Shuttle category, originally projected to cost $857.2 million, Orbiter development has gone up $118.4 million (22%), SRB has gone up $36.7 million (58%) and ET has gone up $27.1 million (34%). SSME funding has been trimmed back by $15.3 million to leave a gross overrun of $166.9 million (Table 7). This brings the total projected Shuttle R & D estimate to $1,024.1 million, an increase of 19.5%.

Table 7: FY 1979 Shuttle funding history*

	Original plan ($xmillion)	Final total ($xmillion)
Orbiter R & D	536.5	654.9
SSME	176.7	161.4
SRB	63.5	100.2
ET	80.5	107.6
Launch & Landing (L & L)	128.1	146.2
Production	454.0	458.0
Totals:	*1,439.3*	*1,628.3*

* This table is an estimate; it will not be less than the totals and could increase

There is need now for an extra $18.1 million for the L & L category due to starvation in earlier years. Congress added $4 million for Orbiter production. The total estimated Shuttle requirement for FY 1979 was $1,439.3 million versus the $1,628.3 million it is now expected to be. FY 1979 will end September 30 and Congress has been formally asked to approve $185 million essential to meet current needs. This is an overall growth of 13% between the estimate made a year prior to the start of that period and the estimate made at the end of the first quarter in that period. It should be emphasised that the case for FY 1979 is provisional but it will not decrease. In summary, the five financial periods between FY 1976 and FY 1979 have seen Shuttle R & D overruns totalling $372.5 million, generating excesses of 0.08%, 0.2%, 7%, 11.5% and 19.5%. respectively. If FY 1979 remains at the currently estimated level, NASA will have spent $6,918.975 million on Shuttle R & D since the project began in FY 1970. Other sums have been spent on facilities construction as shown in Table 8.

Orbiter Production

The issue concerning Orbiter production was brought before the Congressional space committees during FY 1979 budget hearings early last year. Procedural arrangements resulting from the budget request formulated late in 1977 influenced NASA management to change their plan to use Orbiter 101 (Enterprise) as the second operational space flight vehicle; OV-101 had been used during 1977 for approach and landing tests from the top of a Boeing 747. Modifications to prepare the Orbiter for space operations would have cost up to $60 million. Instead, NASA would use components from OV-101 to upgrade STA-099, a structural test article built to load test the airframe in simulation of stresses imposed during flight.

At that time it was believed the pressurised crew compartment, a structurally independent capsule supporting the flight deck and living quarters, could be used in STA-099 but that idea has since been dropped. The proof test programme has been modified so that STA-099 experiences loads up to 120% of design limit instead of the

Table 8: Shuttle Appropriations (millions of dollars) by Fiscal Year

	1970-76	TQ	1977	1978	1979[2]	1980[2]	Total[2]
Orbiter	2019.697	216.3	899.4	813.06	654.9	283.4	4886.757
SSME	404.05	37.9	182.2	197.4	161.4	110.6	1093.55
SRB	95.41	20.4	100.4	104.998	100.2	57.5	478.908
ET	134.34	26.0	84.0	88.03	107.6	59.8	499.77
Launch & Landing	65.126	20.4	77.1	104.012	146.2	99.2	512.038
Technology	44.652	–	–	–	–	–	44.652
Definition	13.8	–	–	–	–	–	13.8
Total R & D	2777.075[1]	321.0	1343.1	1307.5	1170.3	610.5	7529.475
Total CoF	228.42	–	41.035	71.29	31.07	35.7	407.515
Totals	3096.495	321.0	1384.135	1378.79	1201.37	646.2	8027.99
Production	–	–	70.0	41.7	458.0	755.5	1325.2
Totals	3096.495	321.0	1454.135	1420.49	1659.37	1401.7	9353.19

1: Includes $91 million unassigned to categories
2: Preliminary and subject to change
This table replaces the one published in *Spdceflight*, Vol 19, Nos 7-8, page 282 (July-August 1977. Details of the FY 1970-76 period can be found in *Spaceflight*, Vol 18, No 9, page 326 (September 1976).

originally planned 140%. Readers should not think this duality of roles, imposed by economic considerations, generates undue risk. The policy of using proof load test articles for operational flight was effectively demonstrated in the B-1 bomber programme.

In the FY 1979 plan, OV-102 (Columbia) would become the first space flight Orbiter during the second quarter of 1979, STA-099 (Challenger) would be the second in February, 1981, OV-103 (Discovery) the third in September 1982 and OV-104 (Atlantis) the fourth in September 1983. OV-105, the fifth Orbiter, would have been ready by September 1984 but production plans were eliminated by the Carter administration. It has recently been reported in in the journal *Aviation Week & Space Technology* that the then NASA Administrator James B. Fletcher was pressed by the then Chairman of the Joint Chiefs of Staff, USAF Gen George Brown, to plan for a seven-Orbiter fleet but that he declined because he felt the agency stood little chance of getting permission from Congress. However, the fight to save the fifth Orbiter was based upon economics– fast becoming the only way to get Congressional sanction for any technical venture.

NASA testified that the four-Orbiter fleet to the end of FY 1984 would cost $2,522 million in 1979 dollars of which $220 million was money allocated to a fifth Orbiter that the other four would now have to absorb. By comparison, NASA said a five-Orbiter fleet would cost $2,787 million, or $265 million more than the four-Orbiter fleet. The actual cost increase would be $365 million but $100 million would be saved by not having to proceed with a weight improvement programme for STA-099. The first two Orbiters (OV-102 and STA-099) do not have the advantage of improved materials planned for use in OV-103 and OV-104 to provide the full operational capability.

To run its projected space operations for the 1980s, NASA needs three full capability Orbiters and if OV-105 is not commissioned, the second vehicle (STA-099) will have to be brought up to the new standard. Hence an apparent saving of $365 million in production costs is actually cut by 27% ($100 million). Other cost comparibility studies show that if approved in 1979 and deleted at the end of FY 1980, the cost penalty would be $77 million over the four-Orbiter fleet cost of $2,522 million. If, however, a production decision is deferred until that later date, a five-Orbiter fleet would cost $235 million more than if commissioned in 1979. The only way a production saving can actually be achieved is to cancel the fifth Orbiter and never reinstate the need for it because to do so would incur greater cost than going ahead as originally scheduled.

The next step was to examine the repercussions on the entire Shuttle programme. NASA testified that a space programme run with four Orbiters would be less efficient for the period 1980-1991, costing the agency an extra $4,300 million. This is because expendable launchers would have to be retained to fully support the payload traffic requirements and payloads would be designed to fit either Shuttle or expendable rocket. Concern was expressed that the Defence Department would be unable to accommodate all its payload requirements on the Shuttle after 1985 as planned. The Carter administration points out that the new Titan III derivative now being developed for use between 1980 and 1984 could, in addition to serving as gap-filler until the Shuttle can be flown from the west coast, continue in the Shuttle era to fly the excess traffic. This is, in effect, an admission of willingness to forego the enhanced economics of a reusable space transportation system, a clear example of wasteful disinterest in exploiting technology for user application.

In its report, the Senate space committee reminds the administration that, "an efficient, economic, convenient and reliable space transportation system is essential in conducting space science and space applications programmes for the benefit of humanity and in maintaining a leadership role in space activity." It added, poignantly, that these, "were factors underlying the decision to initiate the Space Shuttle development," and that, "further study has not changed the factors present in this decision." Accordingly, acting in the best interests of the programme, it was agreed to allocate $4 million in FY 1979 for long-lead procurement of hardware for Orbiter 105 and to make a final production decision in FY 1981. Until that time there will be official sanction for only four flight Orbiters.

Fiscal Year 1980

During the closing months of 1978 technical difficulties with the Shuttle main engine reached a peak. Following corrective action for turbopump failure earlier that year, an oxygen pump accident on December 27 pushed the planned first flight date back to 9 November, 1979. Problems centred on the two preburner oxidiser valves (for oxidiser and fuel sides of the delivery path) and the main oxidiser valve. Vibration through the latter rubbed components against a steel shim causing it to heat and catch fire in the December incident. Modifications were tested in a sequence

beginning a month later. Because of this, the final set of flight-rated engines could not be delivered to the Kennedy Space Centre (KSC) before May. Orbiter 102 was scheduled for delivery in March but without some thermal insulation tiles that will now have to be applied at KSC. Rockwell has run into difficulty with the tile application schedule, the operation requiring more time and effort than had been expected.

Changes were also introduced to the production schedule. Oribter 102 (Columbia) would begin flying in November 1979 followed by Challenger in September, 1981, Discovery in December 1982 and Atlantis a year later; Orbiter 105 could be ready by the end of 1984. One reason for this delay is that NASA used 1979 production money for development tasks and, as shown in Table 9, depleted Orbiter funds to pay for SSME.

Table 9: Shuttle Production money funding history for FY 1978 and FY 1979

	Original plan ($xmillion)		Final total ($xmillion)	
	1978	*1979*	*1978*	*1979*
Orbiter	38.7	397	29.14	344.1
SSME	3.0	18	12.56	81.3
Launch and Landing	–	11	–	12.4
Spares and equipment	–	28	–	20.2
Totals	41.7	454	41.7	458.0[1]

1: $4 million added by Congressional action.
The table compares production money distribution estimated at the beginning of a fiscal year with the actual spent during that period. For instance, Orbiter money has been transferred to SSME production due to problems with the latter's development.

The FY 1980 budget request is designed to hold total federal outlays to a conservative $531,600 million, a 6.3% increase over FY 1979 which with an anticipated inflation rate of at least 7%, is constraint in real money terms. Against an original NASA plan to request $4,900 million, the OMB (Office of Management and Budget) set its own target of $4,650 million and settled for a compromise budget of $4,725 million. Excluding aeronautics, the NASA space budget request is $4,424.7 million, up only 2.6% on the $4,311.5 million allocated for FY 1979. Readers should note that the FY 1979 figure includes the $185 million supplement for Shuttle R & D. Thus, again, the FY 1980 budget fails to keep pace with inflation.

NASA has not been allowed to request money for any new programme starts, a particularly disastrous situation for the following reason. Two major programme goals for space science in the 1980s come from separate sub-categories: physics and astronomy, and planetary exploration. For the former interests, the scientific community is keen to maintain the valued family of observatory vehicles dedicated to non-optical astronomy. The HEAO series ends this year and NASA planned a gamma-ray observatory to follow the Infra-Red Astronomy Satellite (IRAS) planned for launch in 1981. The gamma-ray satellite would have flown in 1984 had the agency been able to start the project in FY 1981. But prospects for this look dim in the light of two strong contenders for a space science start that year: VOIR and the Halley comet fly-by mission.

VOIR (Venus Orbiter Imaging Radar) is a project designed to provide from orbit around Venus a complete topographic map of that planet. Prevented from using optical cameras by opaque clouds that shroud Venus, radar maps are the only means of determining surface features. VOIR was destined for a May 1983 launch until the NASA budget forecasts all but eliminated the possibility of meeting that date. It was re-scheduled for a December 1984 launch, the last opportunity until 1990 when favourable energy requirements are again within reach. VOIR could carry a synthetic-aperture radar as its only payload, capable of constructing maps of the surface with a resolution similar to those made possible by the Mariner 9 Mars mission of 1972.

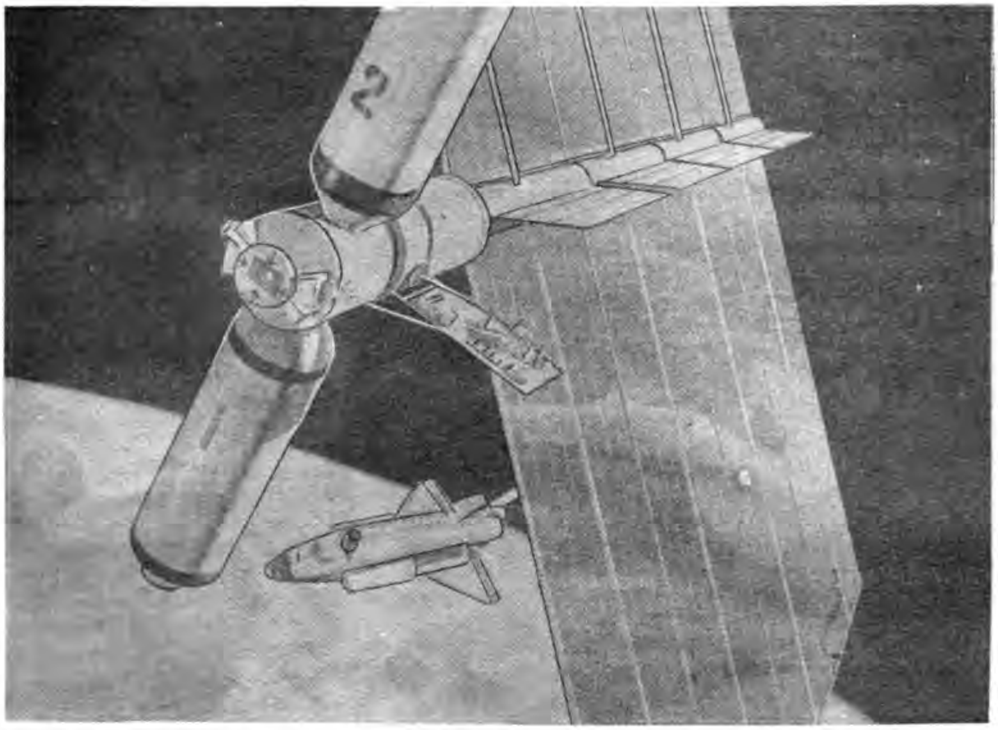
The proposed Halley comet mission would be launched in August 1985 for a fly-by several months later at which time a probe would be sent into the comet's head. Moving on a trajectory that would bring the spacecraft to a rendezvous with comet Tempel-2 three years later, this second objective provides an opportunity to keep station with the comet for 6 months. At the end of that period the spacecraft would move on a slow collision course with Tempel-2, sending information all the way in. If missed as a new start in FY 1981, to be announced next January, NASA is not sure it could start the project a year later and still get to Halley in 1985. That prospect is presently under analysis and it certainly would ease the situation if NASA could start the VOIR project in FY 1981 and the comet mission in FY 1982.

Thus, there are three space science starts jockeying for position: the already twice-postponed gamma-ray observatory, VOIR and the comet flight. The observatory is unlikely to get priority over two highly critical planetary programmes: if VOIR is postponed it will be 1990 before the launch window opens; if Halley's comet is not pursued in 1985 it will be 2055 before the object comes round again. A modest sum injected as new start money for one of these prime goals would have eased the financial bottleneck that now seems inevitable for the next few years. In several respects the need to meet two critical flights simultaneously highlights the dilemma of new start money required by launch-window missions and flights in support of continuing science objectives. A solution could ideally be found if NASA was allowed to build a viable and progressive physics programme—perhaps keeping a constant fund-

Table 10: FY 1979 and FY 1980 NASA budget totals (dollarsx10^6)

Category	FY 1979	FY 1980
Space Transportation Systems	*2,009.5*	*1,904*
Space Shuttle	1,628.3	1,366
Space Flight Operations	309.7	467.3
Expendable Launch Vehicles	71.5	70.7
Space Sciences	*505.4*	*601.6*
Physics and Astronomy	282.9	337.5
Planetary Exploration	182.4	220.2
Life Sciences	40.1	43.9
Space and Terrestrial Applications	*283.9*	*344.4*
Space Applications	274.8	332.3
Technology Utilisation	9.1	12.1
Aeronautics and Space Technology	*376.4*	*419.7*
Aeronautical Research and Technology	264.1	300.3
Space Research and Technology	107.3	116.4
Energy Technology	5.0	3.0
Space Tracking and Data Systems	*302.0*	*332.8*
Research and Development Total	*3,477.2*[1]	*3,602.5*
Construction of Facilities Total	*147.5*	*157.6*
Research and Programme Management Total	*941.469*[2]	*964.9*
TOTAL NASA	*4,566.169*	*4,725.0*

1: Includes proposed supplemental of $185 million for the Shuttle.
2: Includes proposed supplemental of $30.969 million for October 1978 pay increase.



THE NEXT STEP? Space Shuttle Orbiters will be the key elements in demonstrating the feasibility of assembling large structures in Earth orbit.
Rockwell International

ing profile–with launch window missions competing within a separate budget category.

NASA's current planetary exploration programme is a fragmented attempt at bringing together viable mission objectives within a changing political climate. The agency has always had to accommodate the whims and ploys of budget planners and accountants greedy for cuts that once introduced are never rescinded; if present trends continue, the very content of these programmes will be manipulated according to dictates from the White House. Evidence for this comes from the dramatic cut-back in planning schemes kept from public discussion because of the administration's desire to deal with such issues "in-house".

Just two years ago NASA confidently planned to start the Halley comet rendezvous project in FY 1979 for a launch in early 1982 and arrival in December, 1985. A post-Viking Mars project was also planned for a programme start in FY 1979 where scientists and engineers would define the precise requirements of a precursor flight to a sample-return mission scheduled for the early 1990s. The nature of that precursor mission is still in doubt; some would prefer a global survey mission from orbit, others a rover mission where Viking Lander type vehicles roam the surface searching different types of terrain for sample-return mission site selection. However, the precursor mission was expected to be launched in late 1983 on a dual flight carrying the first spacecraft to encounter less than a year later followed by the second in mid-1985. As it turned out, neither Halley nor post-Viking precursor received money in FY 1979.

FY 1980 objectives desired a programme start on a lunar-polar orbiter and a Venus orbiter. The former would have comprised a dual spacecraft flight whereby a polar survey vehicle would have gone into low orbit about the Moon and a second, relay, satellite, gone into a very high equatorial orbit. The relay vehicle would have sent real-time information from the polar orbiter while the latter was on the far side of the Moon. Equipped with sensors similar to those flown on the last three Apollo lunar flights the polar satellite would have provided detailed information on both near and far sides. This mission is very important for the future development of lunar science and selenologists are anxious to obtain data on the far side at a resolution at least the equal of that acquired on the near side. If begun in FY 1980, the project would have reached fruition in mid-1982 at the start of a two year survey. The Venus orbiter is the VOIR mission discussed earlier and if approved as a FY 1980 new start would have been launched in 1983.

Scheduled for a FY 1981 new start, the proposed Saturn Orbiter/Dual Probe mission envisaged a launch toward the ringed planet in 1985 with encounter four years later. Separate probes were to have been sent into Saturn's atmosphere and to the satellite called Titan, a moon close to the size of Mars and one which supports a detectable atmosphere. Saturn lies far from the Sun and misions to that planet require several years in transit.

Because the bottleneck for coming fiscal years contains many apparently more important flights the Saturn mission stands little chance of approval before the mid-1980s, pushing the flight date toward the next decade. Similarly fated may be the asteroid multiple rendezvous mission NASA had hoped to start in FY 1982 and launch in 1985. Encounter with four large asteroids would have occurred in 1986, 1987 and 1988. FY 1983 was scheduled for a funded start on the proposed Mercury Orbiter, with a launch in 1986 and rendezvous in 1988. That mission would have provided an opportunity to map the entire surface of the Moon-like planet, an important flight because lunar science indicates unique aspects about the Moon's history that can be confirmed by detailed observation of a similar body.

Central to NASA's long term planetary goal is the collection and return of samples from the surface of Mars. Bolstered by enthusiasm from the newly elected President Carter, the agency planned to request start money in FY 1983, building toward a dual launch of two separate vehicles in 1990. Arriving at Mars in 1991, the vehicles would land at sites selected partly on the information returned from the precursor mission that in the preferred plan would have been launched in 1983. The two sample return vehicles would arrive back on Earth during 1993. NASA believes it needs an eight year development period for a mission of this type. It is doubtful that the project will begin in the FY 1983 budget because of other demands at that time. The Carter administration has performed a rapid about-face in its attitude toward expensive planetary

objectives of this sort.

In summary, just two years ago the space agency tentatively planned to start the Halley comet project and the post-Viking Mars survey programme in FY 1979, the lunar-polar orbiter and the Venus orbiter (VOIR) projects in FY 1980, the Saturn Orbiter Dual Probe project and the asteroid rendezvous mission in FY 1982, and the Mercury Orbiter and Mars sample-return projects in FY 1983. None of these were actually approved for request by the Carter administration in FY 1979 or FY 1980, the most likely contenders for FY 1981 and FY 1982 being VOIR and Halley comet missions respectively. Because planetary exploration has now moved to the phase where the nearer bodies need sophisticated and expensive landers taking several years to develop, while outer planets require several years to reach, a hiatus could develop from 1985. Beyond that date there is unlikely to be significant flights for at least 7 years, that period being filled with several launches only reaching their objectives after about 1992. With pressure on the entire budget coming from possible Shuttle programmes the mid-1980s could be a lean time for planetary science investment.. As it is the Mars sample-return mission, having now totally replaced manned flight as the "ultimate" Mars misison, will probably not receive a funded start for at least the next 5 years.

In the Shuttle era, new hardware will be essential for the timely development of new ways to exploit space for human benefit. Admirably suited to the task of launching satellites and space probes, the Shuttle will also serve as a laboratory, a space construction base or a platform from which to conduct astronomical experiments. The Orbiter is designed to stay in space for about 7 days. Longer stays of up to a month are possible but only with additional equipment and supplies. An important requirement is electrical power, needed in abundance for both long duration and short lived/high power flight requirements. A solar cell array capable of supplying 25kW was denied a new start in FY 1980. It is to be requested in a supplement planned at the time of writing or added to the FY 1981 budget plan. If incorporated in the late budget it will vie with another project for Shuttle-related funds: the thrust-augmented version of the Shuttle itself.

Certain Defence Department missions planned to begin in the mid-1980s require a performance capability greater than NASA believes will be available with the basic design. To meet the increased requirement, solid propellant rockets will be attached to the sides of the existing large Solid Rocket Boosters. Additionally, to upgrade the Shuttle's overall performance, studies are now being conducted on the feasibility of placing solids underneath the External Tank. But the augmented version using strap-ons will be essential to match Defence needs and NASA is expected to finance the thrust augmentation programme. Study money only is available for FY 1980 although like the 2.5kW power module work could begin immediately.

Another contender for FY 1981 will be the National Oceanic Satellite System (NOSS) project. In this, NASA, Navy and National Oceanic and Atmospheric Administration funds would provide two spacecraft, the first for launch in 1984, to prove the feasibility of moving oceanic survey data from the satellite to the user in time for it to be effectively applied to operational tasks. As a candidate space and terrestrial applications project it will compete in FY 1981 with a demand for more communications research money. After neglecting work in this field because of a belief that industry should take its share of the research bill, NASA has been forced to move back in as the prime R & D house for new communications concepts. A third FY 1981 contender for new start applications money will be a multispectral linear array scanner for Landsat D. It too was denied funds in FY 1980.

On a more general and less specific basis, FY 1980 ousts Carter's electronic search for aliens, denies money for a vigorous Spacelab experiment preparation schedule, constrains study on Earth resources observation and downgrades energy research. Not surprisingly, two projects account for more than one-third the money allowed for space science: Galileo and the Space Telescope. The former envisages a flight to Jupiter beginning in January 1982 culminating in release of an atmospheric entry probe before the "bus" goes into orbit. Space Telescope anticipates a launch in 1983, providing astronomers with an international observatory for optical research. Both are expensive projects and the ST will continue to take a high toll of space science funds for the next 2 years.

Another project that threatens to tighten the pressure for FY 1981 is the Out-of-Ecliptic mission, a cooperative venture with ESA (European Space Agency). Two spacecraft launched together in February 1983 will reach Jupiter in May 1984 (six months before Galileo arrives) and use the planet's gravitational attraction to turn respective trajectories through 90°; one spacecraft will fly over the Sun's north pole, the other over its south pole, obtaining for the first time measurements at high solar latitude.

Space Shuttle money for FY 1980 is down from $1,628.3 million to $1,366 million because development funds are on their way out and the less expensive operations phase is moving in. Total Shuttle funds are inflated for the next 3 years by production money: 55% of FY 1980 Shuttle money is allocated to production, exceeding the development fund. In summary, the FY 1980 budget lacks direction by cutting out projects designed to better exploit the Shuttle and planetary exploration programmes. It severely restricts the options for future years by forcing a financial bottleneck in subsequent budgets and totally fails to demonstrate the ability of the present administration to mobilise the space-borne resources of the United States. But there is a potentially more damaging result of stagnation at the present time.

Over the next few years about $500 million will be freed from the annual NASA budget by transition from Shuttle development to Shuttle operations. If that vacated wedge of financial assets is used for timely development of projects postponed or deferred from earlier years, the Shuttle will in truth have made possible economic space programmes it promised when Nixon approved development. Although the unmanned projects have taken a severe cut during Shuttle development it has enabled the agency to emerge in the third space decade with a viable transportation system.

But if that wedge is used by the White House for reducing NASA budgets by the vacated $500 million the space agency will be stymied. In recent years the Office of Management and Budget has been used by the Carter administration to sift and filter specific projects within the overall NASA budget request.

Two administrative shuffles are essential for the health of what is still the West's most successful space organisation: removal of White House manipulation and use of a financial wedge now emerging for the investment in new programmes essential to future needs. Without such changes NASA has little hope of remaining an effective instrument of science and technology in the face of competition from the Soviet Union and other nascent space-faring groups like Europe and Japan.

BOOK REVIEWERS

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KILOWATTS FOR THE SPACE SHUTTLE

By Dave Dooling*

Introduction

The Space Shuttle will be able to stay in orbit for up to two months with two auxiliary power systems recently approved by the National Aeronautics and Space Administration (NASA).

The Shuttle in its present form can stay in orbit for up to 12 days, a limit imposed by the amount of liquid hydrogen and liquid oxygen it carries. Power available to payloads declines as mission duration is stretched, too. Finally, because launch costs start at $20 million, payloads must have high priority to get more than a week or so in space (i.e., justify more than one launch).

Solar Cells

Quite obviously, the only lightweight renewable power source available is the same one used on satellites for two decades: solar cells. Through research supporting the space station programme and the solar electric propulsion stage, solar cells are now capable of delivering 66 watts per kilogram.

Lockheed Missiles & Space Co. has developed a foldable array capable of producing 12.5 kW in an area 4m x 32m and weighing 190 kg. The array can be extended or retracted at will with an Astromast-type boom similar to the one on which the Voyager magnetometer is deployed. This is a, fibreglass-and-wire strut that packs tightly when rotated and compressed.

The 82 modules in the Lockheed array fold like the pleats of an accordian, but lay flat when deployed. A flight test of a single wing mounted on a Spacelab pallet is planned for an early operational Shuttle mission. Because this will be a mechanical and thermal test, only three of the cell modules will be operating.

Two such wings will power the Orbiter Solar Array System (OSAS) and the 25-kilowatt Power Module, the two power systems assigned by NASA to Johnson Space Centre and Marshall Flight Centre, respectively.

Orbiter Solar Array System

The OSAS will be the simpler of the two systems and the first available. "It's a modification to the orbiter, essentially," said Jerry Craig, manager of special studies at JSC. "It's basically an improvement to the Orbiter power system."

The OSAS will be attached to the end of the Shuttle's remote manipulator system and pointed at the Sun. It will be a little more than a twin solar array, and will return to Earth with the Orbiter.

Stowed, the OSAS will weigh only 950 kg and fit into a small (4.5m x 1.5m) volume across the payload bay, such as over the Spacelab transfer tunnel. In orbit, the manipulator picks up the OSAS and holds it outside the Orbiter. By keeping the OSAS on the manipulator rather than the Orbiter itself, power can be drawn regardless of spacecraft orientation.

Because the OSAS has no batteries, it can provide power only in sunlight. During the night, the Orbiter fuel cells must be powered up. Thus, the additional stay time depends on the orbital inclination (the higher the inclination, the less time in eclipse). Craig said low inclination orbits will be extended to about 20 days, and polar orbits to about 38 days.

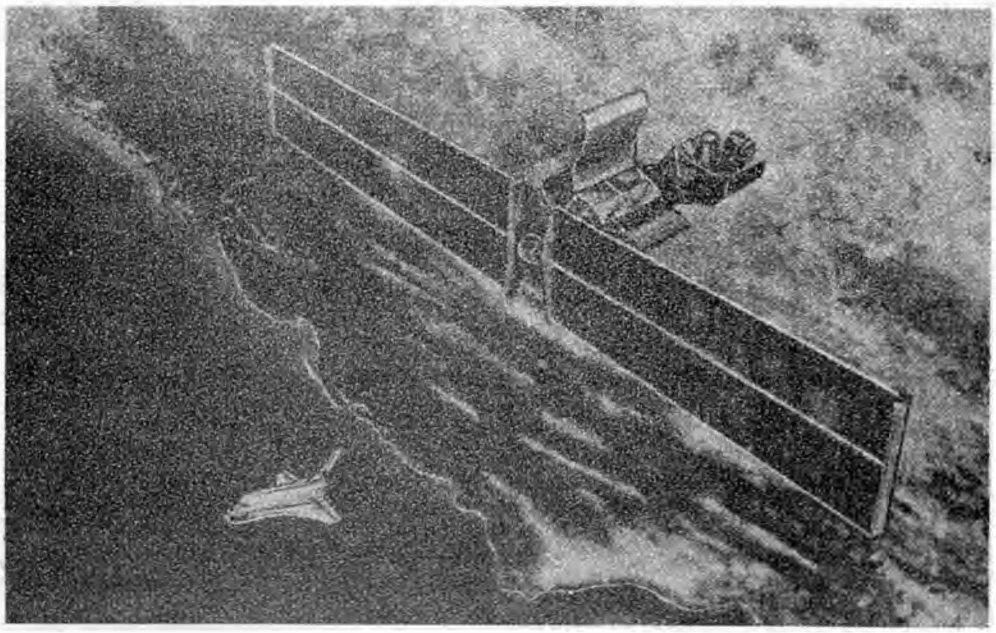
During dayside passes, the Orbiter fuel cells will provide 3 kW of power (idle level) and the OSAS will provide 26kW of power, of which 15 kW will be available to the payload. At night, the fuel cells will run at the full 29 kW level.

Craig said depending on funding—about $45 million will be needed—the OSAS could be available by late 1982. That would allow it to support the Spacelab 2 mission which has about 1,363 kg of payload capability unassigned. Because it is viewed as an Orbiter extension and not a formal "new start," Craig said, budget approval for OSAS should not be too difficult.

25-kW Power Module

By contrast, the more promising (and more expensive) 25-kW power module has had more budget problems than the OSAS. The federal Office of Management and Budget has either cut or reduced requests for money on this effort, despite arguments that it would quickly pay for itself by reducing Shuttle flights to reach long duration in orbit. Congress has restored most funds, and operations are expected around 1984.

* *Huntsville Times Science Editor.*



A free flying power module to be developed by NASA's Marshall Space Flight Center will provide 25 kW of continuous electrical power from solar energy collected by its two 30.6 m wing-like solar arrays. This artist's impression shows the power module with attached 'free-flier' Spacelab pallet loaded with experiments that require extended time in space.

National Aeronautics and Space Administration

The 25-kW power module would be able to support the Orbiter and payload for up to 60 days, and free-flying payloads indefinitely. Additional insulation on the orbiter fuel cell tanks (to keep cryogenics from boiling off before the Orbiter can use them on the return flight) will extend stay times to the food and air that can be carried.

Besides the Lockheed lightweight solar array, the 25-kW power module will be based on hardware and designs drawn from Skylab, standard electronics and technology work in support of space stations. "Our approach was, and still is, to use as much off-the-shelf hardware as possible and reduce the cost," said Jim Murphy, director of programme development at MSFC. "It would be a very straightforward job." Development would cost about $100 million and take about three years. By contrast, some sources calculate that it would save $340 million by reducing Shuttle launches.

Besides power in daylight, the 25-kW power module would provide attitude control and heat rejection to the Shuttle. The 9,090 kg module would use the structural frame and control moment gyroscopes built for the Skylab B Apollo Telescope Mount. Precision will be ±0.05 degrees with the Orbiter and ±0.017 degrees in the free-flying mode.

The thermal control subsystem would be able to reject up to 11 kW of heat from the Orbiter (which can reject an additional 14 kW). Designs are still being examined to reduce damage by micrometeoroids during the 10-year life of the module.

Communications and data handling would be through the Orbiter while docked, and with standard components via the Tracking and Data Relay Satellite while free-flying. Studies are underway to determine the data rate needed to support various free-flying payloads.

Power supplied will vary with the configuration used. In the sortie mode there will be 11 kW for the payload. In the free-flying mode, the payload will receive virtually the full 25 kW. And in the sortie/deployed pallet mode, up to 32 kW is available by running the Orbiter fuel cells at full power. This mode is limited to seven days, though.

Power control will be through new systems developed at MSFC. These include a solid-state programmable power processor that can act as battery recharger and voltage distributor, and a battery reconditioning and protection circuit to protect nickel-cadmium batteries from "memory of fading" which eventually renders cells useless.

The 25-kW module, was conceived by MSFC but soon had competition with the Orbital Service Module drawn up by JSC. However, it was a "clean sheet of paper" design that lacked the technology base developed at MSFC, and with OSAS as the first step in its growth.

"Our approach is really a little bit different," Murphy said. "But it would be awfully hard to bring in something new with the low costs we're talking about."

Future Systems

Another application of the 25-kW power module might be supporting a space station based on Spacelab components. Although Murphy declined to address that application, he said "It would have the capability to provide power and stability and control to anything." Several studies have included the 25-kW power module as a primary space station element.

MSFC is continuing research on advanced power systems that could provide payloads with hundreds of kilowatts of power. A simple upgrading would be the use of reflectors to increase solar cell output without increasing cell area. Fold-up tests in simulated zero-gravity on a KC-135 show that 200 W/kg is possible with present hardware.

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LAKEBED AIRSTRIP

The great white blotch in New Mexico's Tularosa Valley can be seen from the air for a hundred miles or more. Tourists drive out into the gypsum dunes from Alamogordo to view nearby White Sands National Monument. This seems an unlikely place to land a spaceship, but a flat, hardpacked stretch running north and south across the white dry lakebed has been named the backup landing strip for NASA's Space Shuttle Orbiter.

The Northrup strip on the White Sands lakebed was chosen because it remains dry for most of the year. Moreover, Northrup strip is under the flight path of the critical first Earth orbit after a Shuttle launch. Should the Orbiter not be in a safe orbit, or some other emergency force a landing on the first orbit, the spacecraft would be slowed down by a deorbit rocket engine burn high over the South Pacific east of Samoa. As the Orbiter entered the Earth's atmosphere the flight path would cross Baja California and the Mexican state of Sonora until the craft was in the denser atmosphere and the crew would fly it "dead-stick" into Northrup Strip.

Shuttle Orbiter Columbia will make six orbital test flights before the Shuttle Transportation System becomes operational. The first four of these test flights will land at Edwards Air Force Base, California, and subsequent Orbiter landings will be on the 15,000-ft. Shuttle runway at NASA Kennedy Space Center in Florida.

Edwards AFB has a large dry lakebed extending around one end of its main runway that is hard packed and allows an 11-mile rollout for a landing Orbiter. However, winter rains can transform the dry lake into a wet lake, and since there is little natural drainage, water removal is mostly through evaporation.

Standing water on the lakebed at Edwards AFB prior to launch would shift the normal end-of-mission landing to Northrup Strip.

A stiff-leg derrick adjacent to Northrup Strip is being installed for hoisting a landed Orbiter onto the top of the Boeing 747 carrier aircraft used by NASA to ferry Orbiters back to Kennedy Space Center for the next launch. A ground station for the Shuttle microwave scanning beam landing system—a landing and approach piloting aid—will be moved to the Strip from Edwards AFB.

Other landing support equipment to be relocated at Northrup Strip include an S-Band communications van and a mobile tactical air navigation (TACAN) station to provide Orbiter crews with distance and bearing signals from the landing site.

Service workstands, office trailers, towing vehicles and other facilities would be brought to Northrup Strip for Orbiter retrieval and ferry operations. The total cost for installing the derrick and the electronic landing aids is estimated at $1.5 million. Operational costs for retrieving an Orbiter will be about $400,000, and up to 200 NASA and support contractor people would be temporarily assigned to the Alamogordo-Northrup Strip area for a retrieval.

IMAGES OF SPACE

By Gordon L. Harris*

The story of NASA's Public Relations

Introduction

Spurred by Russia's Sputnik, President Dwight D. Eisenhower and the U.S. Congress ventured into a strange area fraught with unknown consequences in 1958, creating a National Aeronautics and Space Administration to explore outer space "for the benefit of all mankind."

The enabling law, referred to as the "Space Act of 1958," contained an unusual mandate drafted by Lyndon B. Johnson, then majority leader of the Senate, and others:

> *"The Administration (NASA), in order to carry out the purposes of this Act, shall....provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."*

Based upon that clear statement of national policy, NASA has for 20 years carried on a broad effort designed to inform the public. Inevitably, agency leaders concluded that information should bring understanding and with understanding should come support, hopefully expressed to succeeding Presidents and Congresses which would assure continuation of the programme at high levels of activity. That assumption has, on occasion, stirred both criticism and affirmation.

Dr. Wernher von Braun put the case bluntly as we talked in New York City early in 1960 where he addressed the American Newspaper Publishers Association: "We must convince people that space is here to stay. It must be recognised as an important element in our progress like the airplane and automobile." He paused, then added: "Otherwise, if the Russians pull off some really major achievement, such as a big space station which we cannot hope to match for some time, the public may become disheartened and Congress could decide to abandon space without realising the consequences!"

WERNHER VON BRAUN, left, with his former Peenemünde colleague, Kurt H. Debus, stand in Vehicle Assembly Building doorway, Kennedy Space Center, after rollout of Apollo Saturn 500F (Facilities Checkout Vehicle) 26 May 1966. This vehicle was of like dimensions and weight to flight Saturns that followed and was built to test VAB equipment, crews and the mobile concept. It lacked engines.

(NASA photo)

Educational Campaign

NASA embarked upon an educational campaign by taking a leaf from the Atomic Energy Commission which tried to persuade the public of the advantages of nuclear development while minimising any hazards. The space agency sought to woo press, television, radio, film producers, magazine publishers and "influence wielders" in general.

Despite media dependency upon NASA for information, photography, press facilities, and other tools of the trade the adversary relationship between journalists and government public relations personnel continues to this day. Agency spokesmen are suspect, the press assumes they will provide only favourable news and hide anything which might prove embarrassing. In fact, NASA has not always acted in ways to dispel press suspicions, reflecting attitudes prevalent in bureaucracies.

The aerospace industry, beneficiary of billions in NASA contracts, furnished notable assistance in promoting space activities. On a lesser scale but significant in some quarters, technical societies offered forums and publications which helped spread the space message. So did Congressional committees closely tied to NASA during the annual budget authorisation and appropriation process. The agency devoted special effort to these Congressmen and Senators following a pattern common to Washington dealings involving Federal departments and both Houses of Congress.

Yet after two decades of space exploits, some failures and other blinding successes, NASA has not succeeded in developing an organised and influential constituency. Labour, farmers, business, industry, veterans, minorities and other groups within the body politic have demonstrated their power to shape legislation in their own interests. Science, on the other hand, seems reluctant to wade into the political cockpit and NASA, whatever the facts, is generally regarded as a scientific institution. The agency may even now feel the growing revulsion towards science and technology which have become scapegoats for common ills.

Without a pressure bloc, however, the programme has not suffered appreciably. In two decades the U.S. has poured more than $65,000,000,000 into the civilian space effort and another $35,000,000,000 into military applications conducted by the Department of Defense. While NASA rarely talks about the exchange, Congress dictated that new technology developed by either would be available to the other.

Measured by dollars or achievements, NASA's success should not be attributed only to its sales campaign. To do so would deny the vision and courage of men like President John F. Kennedy who initiated the Apollo project when the means to accomplish it did not exist, or von Braun who for years preceding NASA preached the gospel of space by every means available. Solid accomplishments by the agency

* *Chief, Public Affairs, Kennedy Space Center, National Aeronautics and Space Administration, 1963-74.*

EXPLORER 1 BLOCKHOUSE ROOM. Karl Sandler, seated, in charge of launch instrumentation and telemetry, Dr. H. H. Bruns standing at left. H. H. Koelle, now of Berlin Technical University, white shirt against wall. Kurt Debus cigarette in hand, looking on. He was launch director for first U.S. satellite.

(US Army photo)

in planetary exploration, communications, weather reconnaissance and real time measurement of Earth resources won support from numerous sources. Then, too, there is the undeniable mystique of space whose grip upon popular imagination has mounted steadily.

NASA's continuing search for recognition and support came into sharp focus at Kennedy Space Center on the Atlantic coast in central Florida where components of space missions came together for the first and last times: powerful rockets, scientific and commercial satellites, astronauts and their spacecraft. As the technology matured new users appeared, NATO and the U.S. military, and other nations among them the United Kingdom, Canada, France, Europe's Space Agency, Indonesia and others.

What Congress expected of NASA in publicising its missions would not apply to foreign sponsors as I pointed out to headquarters. So it was agreed that NASA could talk of its booster or tracking operations while the sponsor determined what, if anything, should be said about his payload.

News Centres

How the agency planned for and supported all media may be illustrated by the Apollo 11 launch of July 1969. Public relations officers at headquarters and field centres, principally those in Houston, Texas; Huntsville, Alabama and Florida developed an 84-page plan covering organisation, security, news centre operations, commentary, news briefings, communications network, photography, guest arrangements, recovery and contractor participation. We established two news centres, at Kennedy for launch, at Johnson Space Center in Houston for the 10-day mission. Specific tasks were assigned to 85 NASA employees and 18 Air Force officers and civilian assistants. U.S. Information Agency linguists came to Florida to interpret for foreign newsmen. Twenty other KSC employees served as escorts for journalists and photographers, or for the wives and children of visiting press who were toured on the base.

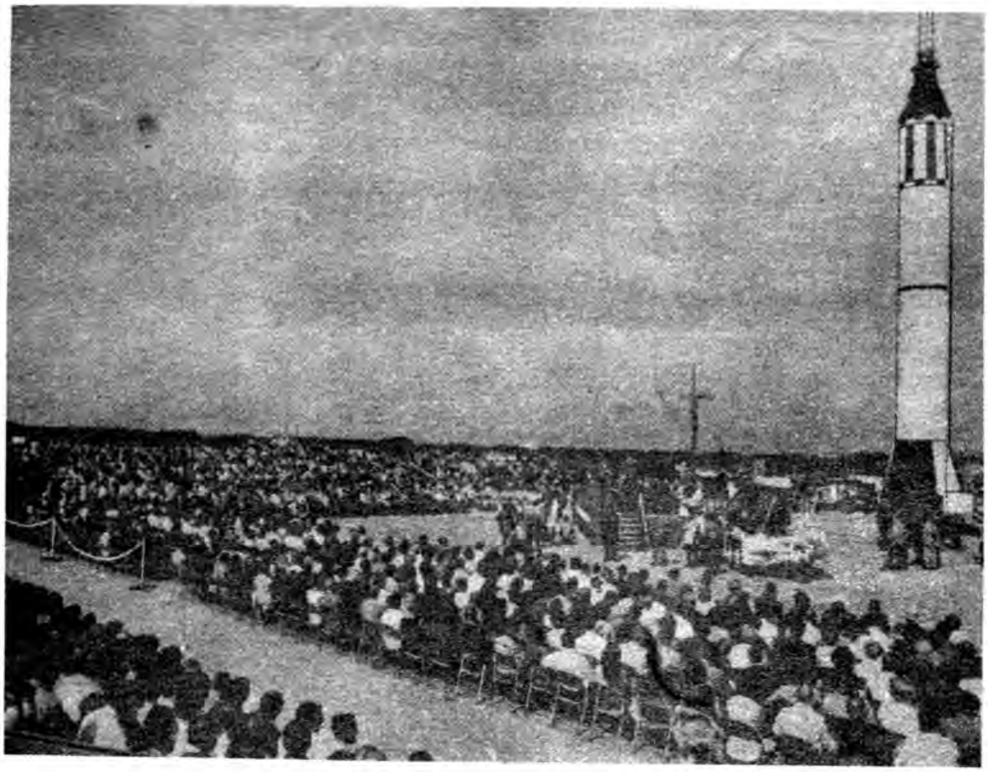
A two-storey office building in Cape Canaveral, 18 miles from the Apollo launch pad, became the principal news centre. Here badges were issued, along with instructions, to newsmen. By launch day accreditations reached 3,497 which was a new record. Television networks assigned researchers, engineers and commentators, the American Broadcasting Company employed 254, Columbia Broadcasting System 244 and National Broadcasting Company 147. There were 445 magazine writers and photographers. As to foreign delegations, Japan sent 118 journalists, the United Kingdom 82, Italy 61, France 53, Argentina 52, Germany 44, Canada 38, Spain 27, Brazil 26, Australia 25, Mexico 21, Switzerland 20, Belgium 19, Korea 15, the Netherlands 10, Chile 9, Venezuela 9, Colombia 8, Costa Rica 7, Sweden 7, and Israel 6. Czechoslovakia, Denmark, Panama, Nicaragua and Peru were each represented by five journalists Bolivia, Greece, Luxembourg, Turkey and Uruguay, three each; India, Angola, Austria, Ireland, Lebanon, Malta, Romania and Yugoslavia, two each while one correspondent came from Guatemala, Egypt, Haiti, Honduras, Iceland, Monaco, New Zealand, Norway, Rhodesia, Somalia, Swaziland and Wales. Eurovision leased commercial satellite circuits to provide real-time coverage to Europe.

Press Briefings

Press briefings commenced 30 days before launch on 16 June when NASA distributed a press kit of 250 pages (by comparison, the press kit for the first two-man Gemini of 1965 counted 48 pages). Astronauts met the press in Houston on 3 July. Beginning at T minus nine days the Florida centre furnished status reports at 9:15 a.m. and 3 p.m. daily. At T minus two days Westinghouse described the compact television system installed in Apollo for astronaut use. Goddard Space Flight Center described the worldwide tracking and communications network. Dr. Kurt Debus, Kennedy Space Center director; Dr. Robert Gilruth of the Texas centre and Dr. von Braun, director of the Marshall Space Flight Center in Alabama met the press. That evening Neil Armstrong, Edwin Aldrin and Michael Collins replied to press questions *via* closed-circuit television as a safeguard against possible infection. On T minus one experimenters

Launch team and community attended 10th anniversary ceremony of Shepard's 1961 flight. Right background: Exact duplicate of his Mercury Redstone vehicle. Plaque marking spot was unveiled by astronaut's wife and mother.

(NASA photo)



explained the equipment they designed for Apollo. Mission officials conducted the final status briefing.

By buses and sedans provided by NASA or private autos authorised for a few newsmen with tight deadlines, the entire press corps was transported to a viewing mound three-and-a-half miles from the Apollo/Saturn vehicle. Bleachers accommodated only 500, seats having been assigned in priority order. Sheer numbers do not necessarily relate to the adequacy and quality of news coverage but they do indicate the workload handled by public relations personnel: Kennedy centre furnished 36,000 black and white photos, 5,250 colour transparencies, and 30,000 feet of 16 millimetre colour motion picture film. Five hundred telephones were installed at the press site, the media paying for this service. Tours were conducted for 2,536 newsmen and families, replies were given to 7,000 press queries. News operations cost the host centre $450,000, one third of our yearly budget for public relations.

Perhaps we were too generous. Some correspondents sold NASA pictures, which cost them nothing. One woman collected 480 prints and sold them to 10 European newspapers. Inquiries to some newspapers after launch confirmed that Florida-bound tourists, with no press connections, talked local editors into giving them accreditation letters. College papers and radio stations, museum officials, advertising managers and others with tenuous press affiliation were badged along with the working press.

Against those possible deficiencies, however, we balanced the results. Television networks reported that 600,000,000 Earthmen saw Armstrong and Aldrin on the Moon. News of Apollo 11 commanded front page space in most newspapers throughout the mission and crew recovery. Editorial comment was universally favourable to the space programme. Foreign media praised the triumph as a turning point in history.

At the White House

This massive effort was not the only concern of Kennedy's public relations office. Dr. Debus pulled in 200 more government employees not involved in launch operations to cope with 18,000 guests invited by the White House (President Nixon made sure that his predecessor, Lyndon Johnson and Mrs. Johnson were on hand), Congress, NASA and its field centres. A fleet of 183 chartered buses hauled guests to a bleachers-equipped viewing site. Vice President Spiro Agnew and the Johnsons mingled with 56 ambassadors, two foreign ministers, 33 U.S. Senators, 206 Congressmen, Cabinet secretaries, 19 Governors, 129 Korean parliamentarians, 225 French industrialists, 50 corporate presidents, scientists, educators, artists, writers, businessmen and just plain friends of someone in authority. Television's Jack Benny and Johnny Carson shared the spotlight. I briefed these and 15,000 other spectators including employees of Kennedy and Marshall centres (the latter chartered 50 buses for the trip) by means of public address systems until Apollo 11 roared out of view.

The Safeguards

Close at hand, but never mentioned, were contingency plans for use in emergencies during countdown or the anxious moments following ignition. Safety engineers determined that if the vehicle exploded, no chunk weighing 100 pounds or more would travel three and a half miles – the distance from guests and press to the launch pad. Tucked in the lunar module riding under Apollo was a nuclear device to power instruments left on the Moon. The Atomic Energy Commission calculated there was a chance in a million that a rocket explosion might trigger a radioactive cloud. Our repeated announcements simply told guests that in emergency, they must return to their vehicles at once, close windows and cut off air conditioning while awaiting instructions. Fortunately and as predicted, the emergency never occurred.

Eleven Apollo launches took place between 1968 and 1972. Measuring public interest by press turnout and guest numbers, Apollos 11 and 17 (last of the series) were by far the most important. Press accreditations for the latter topped those of Apollo 11, so did the numbers of distinguished guests. But on a day-to-day basis, as the site became world famous, we accommodated such luminaries

as President Nixon, German Chancellor Willy Brandt, French President Pompidou, Prince Phillip, King Hussein (a space buff), Charles and Anne Lindbergh, Emperor Haile Selassie, the Amir of Kuwait, Prime Minister Levi Eshkol of Israel, Cardinal Conway of Ireland, symphony conductors Previn and Ormandy, the President of Korea who gave $500 to his limousine driver, promptly returned to State Department; Soviet educators and communications engineers from mainland China, Sir Bernard Lovell, director of Jodrell Bank, first to break the news of Sputnik 1.

Foreign visits were coordinated with agency headquarters and State who provided interpreters and advice. The latter included "don't show him any military facilities," or "don't offer alcoholic drinks or shellfish," (Muslims), or "he understands English but will not speak it," or "don't tell the Israeli that Jordan is coming next week." Sometimes the alleged non-drinkers ordered cocktails at luncheon or dinner. South American parliamentarians got away from escorts in Miami and had no trouble finding ladies of the evening. We learned that Vice President Hubert Humphrey, a repeat visitor, enjoyed brief respites during tours when he could relax with beer and cheese in privacy. Vice President Agnew, a fixture during Apollo, left the launch site as soon as Saturn disappeared for the astronaut quarters, there to watch football or baseball *via* television.

During Lyndon Johnson's administration the launch base became a regular stop for foreign delegations visiting the U.S. but this exploitation tapered off when Presidents Nixon and Ford occupied the White House, blurring the distinction between military and civilian space projects. Besides, we no longer had the magic of Apollo to attract them.

The Early Years

My preparation for this extraordinary assignment began in 1956, two years before NASA emerged, in Army's missile agency commanded by Major General J. B. Medaris. Wernher von Braun was his technical chief, developing Redstone, Jupiter and Pershing missiles for the Army. It was a rare opportunity for a public relations practitioner to represent two outstanding personalities, articulate, dynamic and possessing that elusive quality known as charisma. So it was that I joined Medaris in the Cape Canaveral blockhouse on 31 January, 1958 after two days delay because of unfavourable weather when Army launched Explorer 1, first U.S. satellite and America's answer to Sputnik, reporting countdown to newsmen looking on from a mound one mile away.

The aftermath of Explorer's success taught a valuable lesson in public relations. Medaris insisted upon secrecy in launch preparations because failure might further damage public confidence and U.S. prestige abroad. Without the usual advance drum beating, success brought its own reward. The team won instant acclaim throughout the Free World due, in no small part, to the element of surprise. All copies of the 110-page press kit we assembled for the media disappeared overnight. The packet described the modified Redstone booster and its 30 lb satellite which was packaged by Jet Propulsion Laboratory. Within the orbiter were experiments selected by the National Academy of Sciences.

The press, domestic and foreign alike, "discovered" the principals: Medaris, von Braun, Dr. William Pickering of JPL, Dr. James Van Allen whose Geiger counter identified radiation belts around Earth, and Dr. Kurt H. Debus, former Peenemünde engineer, Army's launch director and later director-builder of Kennedy Space Center.

My presence in the blockhouse was a "first" since Army and Air Force launches were usually conducted secretly. General Medaris pointed to a stool against the wall, telephone nearby, saying "There's your place. If we hear one peep out of you, out you go!" This was my introduction to the private world of men who nursed, fuelled and fired rockets which would one day be dwarfed by mighty Saturns.

Award to von Braun

Naive estimates of the impact success might bring disappeared in a floodtide of public reaction. For instance, demands for von Braun reached such proportions that Army encouraged him to sign up with a lecture agency. The latter set fees for speeches calculated to discourage many claimants and keep Wernher happy in a low-salaried Army job. Among the engagements was a builders' convention in Miami Beach ("some day you will build roads on the Moon") where I took a White House phone call. President Eisenhower wanted him at dinner that evening to receive a medal. With Army's help evening clothes for Mrs. von Braun were flown to a Washington hotel from their Alabama home while clothes were rented for von Braun. Somehow his secretary obtained the correct measurements.

Air service, Miami to Washington, being limited in that day the couple reached their hotel with minutes to spare. They dressed hurriedly only to discover there was no necktie. The hotel manager couldn't help. So they boarded a taxi, arrived at the White House and von Braun explained his problem. They waited while an usher dashed upstairs and returned with one of Ike's ties. Then they entered the East Room where Eisenhower conferred medals upon his former enemy and Dr. Pickering. Seldom in history has such a turnabout occurred. The incident pointed up the importance of small details in effective public relations including ties.

NASA persuaded the President to turn over the von Braun organisation, 5,000 strong, because it desperately needed expertise in rocketry. For some months until the official transfer occurred, I took guidance from NASA on missions that Army launched for the agency.

Able and Baker

The first launch in May 1959, involved two primates riding inside a Jupiter nose cone. Army and Navy had planned the project to test radiation effects in space but NASA contributed $5,000 and assumed control of information about the flight. Some days before launch I proposed naming the animals because of anticipated public interest in these space travellers. The State Department rejected my choice of "Chico" and "Chiquita" (friends in Latin America might take offense). NASA then advised that Jim Haggerty, Eisenhower's press secretary, chose "Able" and "Baker". Unable to dispute this Solomon-like wisdom, I expressed surprise that the White House must decide so small a matter. In time a NASA spokesman appeared at the Cape and convinced the reluctant Air Force commander that agency policy must apply – tell the media and report results to them.

After flawless liftoff we huddled through a long night waiting for word from a small recovery ship 1,000 miles at sea. The weary press clamoured for news as dawn broke. NASA opened a line to the White House. Finally an all-too-brief radio message came through, "Yes, yes." Guessing that two affirmatives meant Able and Baker were alive, we immediately informed press and President. Able succumbed later when sensors were removed from his body and is now a stuffed exhibit in the Smithsonian Institution. Baker, a squirrel monkey, not only survived but at the ripe age of 21 is a prize resident of Alabama's Space and Rocket Center where she continues to receive a steady volume of fan mail from children. The press covering the Cape, irked by military secrecy, loudly supported NASA policy to "tell them first, let them see launch, and tell them what happened." No longer, presumably, could we count upon surprise to evoke headlines.

Voice of Mercury

NASA staged a major public relations coup when seven

KING HUSSEIN of Jordan responds to crowd at Apollo 16 launch. Beside him are Mrs. Gay Debus, left, wife of KSC director, and Mrs. Agnew, wife of the Vice President.

Guests watch liftoff ot Apollo 15 July 26, 1971.

All photos National Aeronautics and Space Administration

Prince Carlos of Spain and his Princess attended Apollo 14 launch. Vice President Agnew with the Princess. On right, Neil Armstrong of Apollo 11 fame, turns to address the Prince.

German Chancellor Willy Brandt in firing room after launch of Apollo 13 in April, 1970 with Vice President Spiro Agnew. KSC Director Kurt Debus visible over Brandt's right shoulder.

First President to witness manned launch at Cape, Richard Nixon brought Mrs. Nixon to Apollo 12 in heavy downpour. NASA Administrator Thomas Paine holds umbrella at right.

U.S. Senator and Mrs. Edward Kennedy witnessed Apollo 8 launch 21 December 1968 at the launch base named after the late John F. Kennedy.

Nearly 3,500 accredited newsmen covered the Apollo 11 launch, including this partial grouping at the press site, located 5.6 km from Launch Complex 39A. Minutes before ignition most left their viewing mound to line the shore of the Turning Basin.

military pilots were selected for the astronaut corps. Within hours the names and faces of Alan Shepard, John Glenn, Virgil Grissom, Walter Schirra, Gordon Cooper, Scott Carpenter and Donald Slayton became familiar to the public. Everyone wanted to know everything about these heroes, introduced as the first humans who would leave Earth for adventures in space. First, that is, until the Soviets flew Yuri Gagarin in Earth orbit in 1961. Again the Russians had beaten the U.S.

Until that stunning event the new space pilots were photographed, interviewed, feted, exploited and paraded before Congress. NASA had found its most effective salesmen. *LIFE Magazine* negotiated an exclusive contract for personal stories and access to their families, paying $500,000. The agency bore the brunt of press criticism for this turn of affairs, defending the arrangement because astronauts would risk their lives while receiving government salaries and small insurance policies. With the addition of astronauts, NASA no longer had to court the press, now public relations personnel ran hard to satisfy press demands. To "protect" the seven from press and public the agency borrowed Lt. Col. John "Shorty" Powers from Air Force. He would gain recognition as the "voice of Mercury" when he reported space missions of the pioneer series of solo flights 1961-1963. Ten years later Kennedy centre feted Shepard, first to fly, and Glenn, first American in orbit, now U.S. Senator from Ohio. True or not, Alan sprang a surprise upon his family and hosts when we gathered at the Mercury launch pad. He knew, so he said, that physicians would listen intently to heart beat and pulse, telemetered to their stations from the capsule, as liftoff neared. To make sure they didn't halt the launch, he arranged to have those measurements recorded several days earlier and played back the tape in the final moments.

Astronaut humour is a cherished part of NASA tradition. Walter Schirra, who flew Mercury, Gemini and Apollo, told a delighted audience that "When I was locked in the spacecraft, checking dials and gauges, I suddenly realised that every part in the Atlas missile had to function perfectly if I was to survive. Then it dawned on me that every part had been supplied by the lowest bidder!" Not true but still funny.

Launch team members at the Cape surprised Glenn as he awaited liftoff. Following his checklist John reached the item when he would peer into a telescope. He saw a beautiful pinup girl and a legend reading: "It's just you and me in space, John baby!" Glenn chuckled but his flight had to be postponed. Next time he ran down the list he saw an old, bedraggled scrub lady with the words: "What did you expect after yesterday's fiasco?"

Apollo Fire

More pilots joined the corps for Gemini, the two-man missions testing rendezvous and docking techniques essential for Apollo in 1965 and 1966. Ten flights were conducted with minor glitches at two-months intervals. Apollo's first fateful mission, an Earth orbit test of crew and spacecraft, would be flown by Virgil Grissom, veteran of Mercury and Gemini; Edward White, first American to "walk in space" during Gemini, and Roger Chaffee, making his debut. The astronauts occupied their Apollo for a day-long test on 27 January 1967, fully suited and breathing pure oxygen as did the crews of all previous manned flights. This was to be the final intensive test of Apollo 1 before launch.

In Washington that day President Johnson entertained the Soviet ambassador and representatives of 58 other nations signing a treaty forbidding weapons in space. That evening he hosted a reception at the White House for John O'Connor, retiring Secretary of Commerce. During the festivities the President was handed a note from James Webb, NASA administrator. It told him the astronauts perished in a spacecraft fire.

NASA entered its darkest hour and the future of manned space flight hung in the balance. It may seem incongruous to talk of astronaut jokes and death in juxtaposition, but that was characteristic of the strange rhythm in this fast moving adventure, the humour born of supreme confidence in themselves and their equipment, convincingly demonstrated by unbroken successes of Mercury and Gemini, 16 missions in all.

The agency had planned thoroughly for anticipated happenings in terms of public relations support. Contingencies in space or on the Moon were foreseen. No one grasped the

Visitors Information Center at NASA launch base. Thousands of autos parked in rear suggest size of crowd during Christmas holidays 1976. Anyone may drive to the place during business hours without being stopped by guards.

(NASA photo)

obvious fact that catastrophe also occurs on Earth, in this case on the launch pad.

We followed established procedures. My news chief, Jack King, occupied a console in the blockhouse near test manager Rocco Petrone. At 30-minute intervals he phoned resident correspondents of Associated Press and United Press International reports on progress of the test. I returned home at 6:30 p.m. 30 miles from the Cape and took Jack's subdued phone call at 6:37. He reported fire in Apollo and said the situation looked bad. I tried to reach headquarters contacts and finally spoke with the wife of one, telling her what happened, asking her to inform her husband and any other NASA associates. Then I drove to the Cocoa Beach news centre, unlocking the door at 7 p.m. Lights flashing on incoming phone lines indicated the alarm had spread. All I could do was confirm the fire.

Calls to assistants summoned help. Within the hour 11 of my staff and eight contractor employees familiar with our work reported for duty. We kept lines open to King, to Paul Haney, who replaced Powers in the Texas centre, and NASA headquarters. King was our sole source of information throughout the long night. He kept in touch with Petrone, Donald Slayton, chief of the astronaut office and present at the test, and Major General Vincent Huston, test range commander. Because the launch complex was on an Air Force station, Cape Canaveral, fire fighting and emergency medical assistance were Air Force responsibilities.

Julian Scheer, NASA's top public relations official, came on line at 7:20. He was trying to reach Webb so the administrator could inform the President. After discussing the situation with King, Scheer and Haney we made the first announcement at 7:40, simultaneously released in Houston and Cocoa Beach:

> *"There has been an accidental fire at Launch Complex 34 during the plugs-out test of the Apollo/ Saturn 204 involving fatality. More will be announced after next of kin have been notified. The prime crew was in the spacecraft."*

That final sentence told the press Grissom, White and Chaffee were involved. Some newsmen sharply criticised us for delaying the confirmation of deaths. I take full responsibility. It is traditional in the U.S., observed by law enforcement agencies, hospitals and the military not to identify victims of sudden death until families or survivors have been informed. News people contended this rule should not apply to celebrities. I do not agree. The fact was that Slayton had confirmed the deaths to King only seconds before the announcement.

The next official statement at 8:30 identified the three men. By that time Slayton could confirm next-of-kin notifications.

As night wore on the news centre answered queries and provided what little factual information we possessed: communications problems repeatedly delayed the test, engineers in the blockhouse watching television monitors saw a flash, then white flame, then dense smoke engulfed Apollo. There was an inner hatch, outer hatch and boost protective cover on the spacecraft. It required five minutes or more to open hatches under normal conditions. Names of 27 pad workers who suffered burns and smoke inhalation trying to open Apollo were given to the press. At midnight we reported that Dr. Debus, KSC director; Dr. Robert Gilruth, director of the Texas centre and Major General Samuel Phillips, Apollo programme director, were flying in from Washington. They began interviewing test officials immediately. Next morning NASA appointed a board of inquiry. I took Phillips to the press site where he gave newsmen a status report and answered questions. One newsman selected by his colleagues was shown the charred Apollo and reported what he saw to the media. The press witnessed transfer of flag draped caskets to a plane which carried them to burial sites.

NASA released pictures of the spacecraft, the crew, and Astronauts Frank Borman, James Lovell, Donn Eisele and Walter Cunningham as they testified to the inquiry. Twice-daily reports of the board's work were furnished to the press.

This is not the place to reexamine the board's work or that of the Congressional investigations which followed. In his book, *Carrying the Fire,* Michael Collins gave his personal

reaction: "My God, what an obvious thing and yet we hadn't considered it....the 100 per cent oxygen environment we used in space was at reduced pressure of five pounds per square inch but on the launch pad the pressure was nearly 16 pounds. Light a cigarette in pure oxygen at 16 psi and you will get the surprise of your life as it turns to ash in about two seconds. With all those oxygen molecules packed in there at that pressure any material generally considered combustible would instead be almost explosive. And combustible materials – books, clothing, supplies – there were aplenty, also plenty of ignition sources. There was supposed to be none of the latter but let's face it, the inside of a Block 1 spacecraft was a forest of wires, a jungle of wires, a jungle which had been invaded by workmen changing, snipping, adding and splicing until the whole thing was one big potential short circuit."

NASA and Apollo survived. President Johnson and senior Congressmen refused to stampede while the agency changed key managers, installed quick opening hatches, and decided to employ a nitrogen-oxygen atmosphere in ground tests. In October, 1968, boosted by the same Saturn, Walter Schirra, Donn Eisele and Walter Cunningham flew Apollo and pronounced the spacecraft ready for the Moon. Frank Borman commanded the Apollo 8 mission two months later which orbited the Moon at Christmas. That memorable event restored faith in the agency, its space systems and the astronauts.

Once again, however, the element of surprise in the shocking tragedy heavily influenced the media coverage and public response. We in NASA public relations felt that having been blooded, no future emergency could take us by surprise.

Unlucky 13

Human emotions had been drained by the triumphs of Apollos 11 and 12 and press interest had noticeably waned when Apollo 13 took off 11 April 1970. A last minute substitution, the only one of the programme, put John Swigert in the spacecraft in place of Thomas Mattingly because of concern that Mattingly was about to develop measles. For 55 hours the flight proceeded smoothly. Then, without warning, the crew heard an explosion and reported to Mission Control. It was 10 p.m. in Florida. An aide listening to the space-ground conversations alerted me.

Again I hurried to the news centre, summoned help and opened a line to Houston. Astronaut Richard Gordon, who chanced to be in the area, drove to the Kennedy training building for flight crews and joined the rescue operation. Press in Florida and Texas newsrooms heard every word spoken by the crew and ground controllers as engineers on Earth worked out emergency solutions. The story assumed worldwide prominence. NASA fed the voice circuit into television and radio so the public could hear the astronauts as they began manoeuvres to orbit the Moon and hopefully return safely, employing their lunar module as a lifeboat because Apollo lost its oxygen supply.

No one thought of secrecy. Apollo flew by the Moon 150 miles from its surface and turned towards Earth. Two hours later the lunar module engine fired, propelling the spacecraft towards the same Pacific Ocean area where the crew would have splashed down after exploring the Moon. On 17 April, 138 hours from launch, 80 hours after the ordeal began, the crew jettisoned Apollo, separated Aquarius two-and-a-half hours later and dropped into the ocean. President Nixon greeted them in Hawaii with their families.

Cliffhangers of this kind defy planning but they make news. NASA made sure the press got the information promptly, without embellishment, and continued the flow through official inquiry, adoption of preventive measures and the conclusion of the probe. Response from public, press and Congress was favourable.

Skylab and ASTP

The Moon, it turned out, was one thing, an 80-ton space station, Skylab, something else so far as press and public interest were concerned. Despite NASA's best efforts to heighten interest, smaller crowds and fewer press turned out for the initial 1973 launch and three manned visits following. Networks failed to cover crew returns, having advised that kiddie cartoons drew larger audiences than man-in-space. The Apollo-Soyuz mission of 1975, linking U.S. and U.S.S.R. crews in orbit, also fell far short of Apollo enthusiasm. It made all the difference if men flew 250,000 miles to the Moon or 250 miles into orbit.

Spreading the Word

NASA continues to spread the word by employing virtually every tool in its public communications programme: millions of publications, television films and radio tapes routinely supplied to hundreds of stations, travelling exhibits (the Apollo 11 spacecraft was exhibited in 50 State capitals), and encouraging its scientists and engineers to participate in seminars, conventions and public forums.

The Kennedy Space Center embarked upon an unusual project late in 1963, prodded by Congressman Olin Teague of Texas who wanted the public to see the space launch base, then in construction. A year later motorists could safely drive through the place on Sundays. On 27 December 1965, we recorded 14,008 autos carrying 33,000 people through the Kennedy centre and adjacent Cape Canaveral. NASA agreed to put up $1,000,000 for prefabricated visitor facilities and daily bus tours commenced 20 July 1966, conducted for NASA by Trans World Airlines.

More permanent buildings were opened on 1 August 1967. Since then more than 13,000,000 people have toured the area, viewed films of space and exhibits displayed indoors. The enterprise is self-supported, modest fees charged for the 50-mile tour, and the sale of food, drinks and souvenirs pay all costs and a 10 per cent management fee to the contractor. Other income has been invested to improve facilities and add parking areas, amounting to $2,000,000 in 10 years.

The proximity of Disney World 50 miles west of KSC has contributed to the eminently successful programme, open to all comers 364 days per year. The centre closes only on Christmas Day.

Special tours were scheduled for those desiring to witness launches, including unmanned Delta and Centaur rockets transporting planetary probes and satellites as well as the final Apollos, Skylab and the joint mission with the Soviets. In the offing is the debut of Space Shuttle, NASA's reusable transport, which is confidently expected to spur interest in space beginning late in 1979 and flying at a rate of up to 40 missions annually from Kennedy centre and returning to the Florida base each time.

Foreign visitors especially were frequently prompted to comment upon the openness of NASA launch operations, a concept utterly strange to them. The results, however, have confirmed the wisdom of lawmakers who 20 years ago decreed that we should "provide for the widest practicable and appropriate dissemination of information."

PROOFS DELAYED BY POST

Failure of the Post Office to forward proofs from our former offices at 12 Bessborough Gardens, resulted in certain proof corrections not being embodied in our June and July issues.

In particular, the statement above the article on "India's Earth Resources Satellite" (July 1979, p.300) failed to record that the launch, expected in February, had been delayed.

MISSIONS TO SALYUT 6

By Gordon R. Hooper

Continued from the July issue]

PART 8

This article concludes Gordon Hooper's coverage of the second phase of manned operations with the Salyut 6 space station, and with it, his series of contributions on Soviet manned space flights. For a variety of personal reasons and the greatly increased information flow from Moscow, it has become increasingly difficult for him to find the large amount of time necessary to research and compile the Salyut articles. We wish to thank Mr. Hooper for the valiant efforts he has made. The present article brings to a close a series begun in 1974 with the mission of Soyuz 14/Salyut 3 and, since that time, all 18 launches (the only exception being ASTP) have been covered. Readers will be pleased to know that his series on "The Cosmonauts" will continue to appear.

Progress 4

On 3 October 1978, at 23.09 (all times expressed in GMT), the Soviet Union launched the Progress 4 cargo craft "as part of the programme for long term operation of the Salyut 6/Soyuz orbital scientific research complex....with the aim of supplying the Salyut 6 station with fuel for the engine installation and with various cargoes, and of further improving the construction elements of the onboard systems and equipment of the automatic cargo craft."

Progress 4 was inserted into an initial orbit with the parameters 266 x 191 km (165 x 119 miles) x 88.8 min x 51.7°, and on 4 October, two trajectory corrections were carried out. In the Soviet Union, the cargo craft's launch actually took place on 4 October (i.e., at 02.09 Moscow time), the 21st anniversary of the launch of Sputnik 1 on 4 October 1957.

Onboard Salyut 6, Vladimir Kovalyonok and Alexander Ivanchenkov documented the results of their research and experiments, and carried out visual observations and photography of the Earth.

On 5 October, the crew were scheduled to carry out a medical experiment on heat exchange, designed to study cooling properties in a closed environment, and characteristics of the organism's thermal regulation in weightlessness. In their 110 days in orbit, it was reported, they had carried out 50 smelting experiments and taken more than 20,000 photographs of the Earth.

A *Novosti* report on the tour of the GDR by Bykovsky and Jähn quoted Bykovsky as saying that their reception had been so enthusiastic that they sometimes felt that "they were walking on air, a similar feeling to weightlessness in space." He was speaking at an international press conference in Berlin. At the same conference, Jähn showed photographs that he had taken with a 35 mm camera as they undocked in Soyuz 29. The cosmonaut revealed that he had had two cameras in space – a Pentacon-6 and a Praktika EE2 with which he had taken the photographs of the undocking, using different lenses.

Another *Novosti* report featured an article by Dr. Heinz Kautzleben about the MKF-6M camera. He wrote that the original MKF-6 camera used onboard Soyuz 22 was only designed for eight days of operation. The modified version, the MKF-6M, as used onboard Salyut 6, was designed to function for two years and is able to withstand greater loads, up to 100 g in fact. Loads of up to 5 g were experienced during launch, and during docking, up to 40 g.

The MKF-6M had several advantages over other methods of Earth observation from space, including the ease of operation and its use for specific tasks. It gives exact photos with high definition. With photos taken at a height of 250 km (155 miles), the scale is 1:2 million, with each photo covering an area about 115 x 165 km (71 x 102 miles). To examine the photos, another instrument from the Carl Zeiss Jena factory is used – the MSP-4 multi-zonal projector.

With the Salyut in a 350 km (217 miles) orbit, the area of each photograph was approximately 160 x 230 km (99 x 143 miles). While the MKF-6M camera was in use, photos were taken simultaneously by an AN-30 aircraft flying between 6,000 and 8,000 m (19,685 and 26,247 ft). These photographs covered an area approximately 3.4 x 4 km (2.1 x 2.5 miles). On the actual ground surface being photographed, specialists took measurements of soil humidity, ripeness of crops, and other agricultural data. Comparison of the three data sources aids the analysis of the multi-zonal photography.

On 6 October, at 01.00, Progress 4 docked with the Salyut 6 space station, the entire operation having taken place automatically. Control was maintained by the ground communications network, which included the research vessels *Borovich, Chumkin,* the *Kosmonaut Vladimir Komarov* and *Kosmonaut Pavel Belyayev.* The Progress brought to Salyut 6 1,300 kg (590 lb) of equipment, scientific apparatus, food, water, air, letters and gift parcels, newspapers and magazines, a new tape recorder and music tapes, and 1 tonne (0.98 tons) of fuel.

Some of the specific items delivered were: fur boots, as requested by the crew; [*As blood moves to the upper extremities of the body in weightlessness, it reduces circulation in the lower parts of the body; result cold feet!*]; new Penguin suits, to replace the existing ones which were nearly worn out; assorted foods, again in response to a request by the crew, they were sent an increased supply of meats, together with strawberries, fresh milk, onions, garlic and curds with nuts; to provide a greater degree of privacy, blinds were supplied which could easily be opened and closed to section off areas of the living quarters. Other items delivered were camera films, fresh water, and lithium hydroxide canisters for air purification.

After docking, the cosmonauts checked the airtightness of the docking unit and then rested. In the afternoon, they opened the transfer hatch and began unloading. *Tass* announced that the crew would take 10 days to unload the Progress and transfer to it "the wastes of cosmic life". The pumping over of the fuel, an entirely automatic operation, was the main aim of the mission. Once unloading had been completed, the cosmonauts were to complete a number of technological, medical and biological experiments before mothballing the station and returning to Earth.

On 7 October, the day's programme included cleaning the complex's working areas, and stocktaking the Salyut's equipment together with the cargo delivered by Progress 4. They also prepared the station for refuelling by pumping compressed gas from the tanks of the combined engine installation.

On 9 October, *Novosti* reported that Kovalyonok and Ivanchenkov would be returning to Earth towards the end of October. After breakfast, the two men began unloading Progress 4, and continued preparing for the fuel transfer operation.

Work Programme

Their programme of Earth observations included studying the timber massifs of Siberia and the Soviet Far East using the manual spectrometer. This enabled them to differentiate between deciduous and evergreen trees, to assess better the size of areas subjected to forest fires, and to accurately

determine stocks.

On 10 October, the cosmonauts continued their unloading operations. They dismantled used equipment and transferred it to the Progress. They had already transferred more than 300 kg (136 lb) of food and water to the Salyut. According to the Flight Director, the cargo included 46 kg (21 lb) of air and 176 kg (80 lb) of drinking water. There were also new sample-ampoules for materials processing experiments.

On 11 October, they were reported to have completed the greater part of the unloading work. They had transferred to the station's holds food containers, water, photographic materials and personal hygiene articles. They had also installed new air and water regenerators, and prepared the tanks for refuelling.

On 12 October, the cosmonauts had a medical check-up, during which their cardio-vascular systems were studied. Radio Moscow reported that they had begun wearing the Chibis suits to prepare them for their return to Earth.

Among the goods delivered by Progress 4 was a supply of Eleutherocc, a tonic which "promotes normalisation of all the body's functions, and in determined doses, acts as a stimulant." Relatively prolonged use of Eleutherocc forces the body to work in conditions of stress and of intensified functioning of all the systems of the body. The crew, it was said, were waiting impatiently for this fresh supply, which was prepared by a Moscow pharmaceutical enterprise. Eleutherocc was said to play a special role, particularly in the final stages of a space flight.

Radio Moscow reported that Kovalyonok and Ivanchenkov had discovered that the Urals did not begin where present maps show, but in Central Asia, or even further South. They had also discovered new lakes in Iran and new islands in the Amazon. It was stated that the cosmonauts' eyes, trained through experience, could pick out many details which do not show up on photographs.

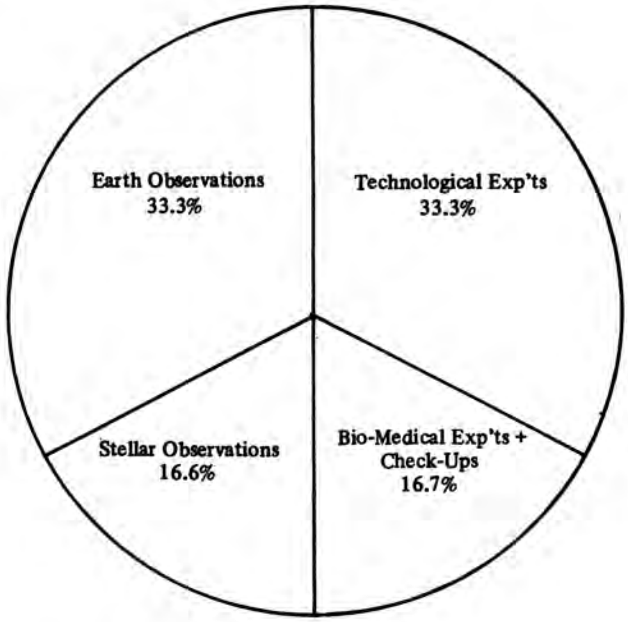
On 13 October, the refuelling and unloading operations were completed, both having taken only half the planned time. During the day, the cosmonauts carried out Earth observations at the request of meteorologists to help draw up more accurate weather forecasts. They also studied the planet Venus, and discovered that it blinks like a star, even though from Earth it appears to have a steady brightness.

On 14 October, the cosmonauts had a rest day, during which they did their usual physical exercises and systems checks, and talked to their families over the radio link with MCC.

Radio Moscow reported that the problem of resting in orbit was far from solved. Even two days rest a week was insufficient to fully restore their strength. This was put down to a variety of reasons: they were working in very unusual conditions; it was impossible for them to completely disengage themselves from their work programme; and the "complex of measures which would make it possible to restore one's strength effectively whilst in orbit is, as yet, not perfect."

It was thought that keeping busy with hobbies and/or favourite activities would help to recharge the batteries emotionally of the crew. But even this had provided a few surprises, as their favourite activities tended to change during the flight. At first, they carried out medical research, then they conducted visual observations, and then, finally, their work with the onboard sub-millimetre telescope gave them the most enjoyment.

The two cosmonauts had stressed several times that the monotony of the physical exercises exhausted them considerably. Therefore MCC sent up several new music cassettes with a specially selected musical accompaniment for physical training. This wasn't expected to have very much effect, as the cosmonauts already had a wide choice of music onboard Salyut 6. However, Kovalyonok said that the music was excellent, and whilst playing it, he hadn't noticed how the time passed during exercising.



Allocation of Study Time Onboard Salyut 6.

On 15 October, Radio Moscow reported that even though the crew were supplied with luxury tinned foods, after a while they complained that they didn't like them. Instead, they asked for onions, garlics, potatoes and gherkins – anything fresh.

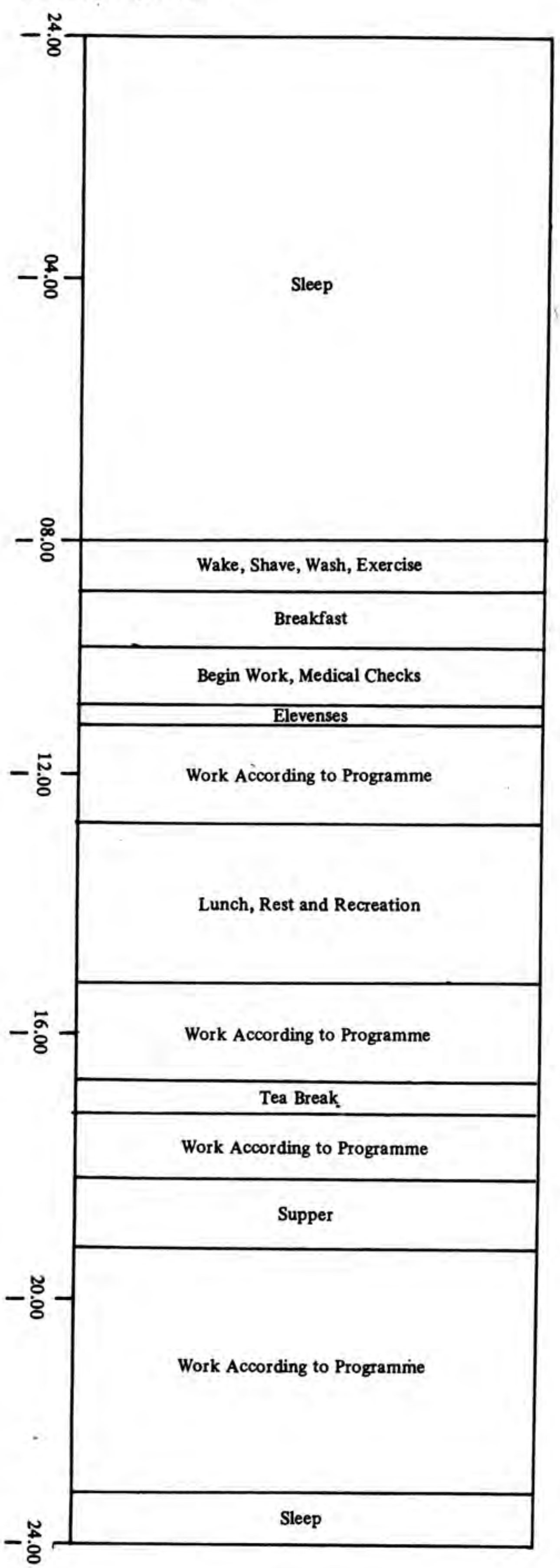
On 16 October, Radio Moscow reported that during their stay onboard Salyut 6, Kovalyonok and Ivanchenkov had, through their photographic sessions, obtained as much data as an aerial survey would produce in two years, or a ground expedition in 80 years. They had also carried out over 30 smelting operations using the Splav and Kristall furnaces.

On 17 October, the cosmonauts had a complete medical check-up, and this was continued on 18 October using the Chibis suit and Polinom-2M equipment. They also conducted a further Kristall experiment.

On 19 October, the cosmonauts carried out visual observations and photography of the world's oceans. During the day, they fired the Progress 4 engines to carry out a trajectory correction, increasing the complex's velocity by some 6.5 m/sec (21.3 ft/sec).

On 20 October, they made a second smaller power manoeuvre. Asked why the operation had been spread over two days instead of the usual one day, Prof. Igor Konstantinovich Mazhinov explained: "By doing this, we have an opportunity to define more accurately – after the first manoeuvre – the actual parameters of the orbit, to allow for small errors which have arisen in the first manoeuvre and to carry out the second manoeuvre more accurately." During the day, Kovalyonok and Ivanchenkov also carried out control checks on the systems of Salyut 6 and Progress 4, monitored their biological experiments, observed ocean currents in the Southern hemisphere, and photographed various areas of the Soviet Union for economic purposes.

On 21 October, the two men had a rest-day during which they did their usual physical exercises, and also cleaned the station. They also conducted biological experiments with higher plants, took photographs of the Earth, and, in the evening, conducted a Kristall experiment. They also held a



The Working Day Onboard Salyut 6.

communications session with Viktor Sviridov, a representative of the Priroda (Nature) Centre, who asked the cosmonauts to draw a map of the flow of the biggest rivers in the Atlantic Basin to be used by Kaliningrad oceanologists and fishermen.

October 22 was the second day of rest. On 23 October, many hours were set aside for medical examinations. Two smelting experiments were also carried out to produce alloys of cadmium, sulphide, and cadmium-mercury-tellurium. The parameters of the Salyut 6 orbit were 376 x 359 km (234 x 223 miles) x 91.7 min x 51.6°.

Smelting Experiments

On 24 October, Kovalyonok and Ivanchenkov carried out control checks of the control systems of Progress 4 and the Salyut. They did their usual physical exercises, implemented operations under the programme of biological experiments with higher plants, photographed the Earth's surface and carried out smelting experiments in the Kristall furnace. At 13.07, Progress 4 was undocked from Salyut 6, the operation being monitored by the cosmonauts.

On 25 October, the men concentrated on technical documentation, biological research, and a further Kristall experiment. Meanwhile, in Poland, the results of the tests and experiments carried out by the Polish cosmonaut, Miroslaw Hermaszewski were presented at a meeting of the Polish Academy of Sciences' Space and Research Committee. Also on the agenda were the plans for future Polish participation in the Intercosmos programme for the next decade.

Writing in *Pravda*, Alexei Leonov said: "The construction in the Soviet Union of orbital stations with changeable crews and of the Progress cargo craft marks a step forward on mankind's way towards interplanetary travel. Soviet scientists regard such complexes as man's highway to outer space."

In Leonov's opinion, stations similar to Salyut 6 may become "cosmodromes in orbit" – launching sites where cosmonauts would take part in putting together interplanetary ships and testing their systems and pass through a period of acclimatisation.

On 26 October, at 16.28, the braking engine of the separated Progress 4 was switched on, causing a controlled re-entry over a pre-set area of the Pacific. During the day, the Salyut cosmonauts photographed the Earth and world oceans, and carried out further technical experiments.

On 27 October, Radio Moscow gave details of the "garden" onboard Salyut 6. On a black plastic panel there were a number of compartments containing seeds. A nutrient solution was fed to the seeds from below and artificial sunlight was provided from above. The roots then grew into the solution, while the shoots grew 'upwards', seeking the artificial sunlight.

A special kind of wheat – a short stalked [less than 305 mm (12 in)] very heavy grain-yielding wheat – was produced in the garden, taking 63 days to produce ripe grain. The cosmonauts had also grown onions, cucumbers, tomatoes, garlic and carrots.

During the day, the crew used the Kristall furnace to produce lead telluride alloys. In a communications session, Kovalyonok said "The remaining work here is coming to an end and we are now making preparations for landing....The preparations are carried out at two levels: We are preparing ourselves both mentally and bio-medically. We are checking our bodies to see how during the prolonged flight they have been able to endure weightlessness and how they will take the g-loads during the return to Earth."

On 28 October, the men spent the morning logging the results of the week's work. It was a day of active rest, including the usual regime of physical exercises, communications sessions, and housekeeping. On 29 October, the two men had their last day off in space, during which they were congratulated by flight commanders on the successful completion of the scientific programme.

During a TV communications session, Anatoly Karpov, the victorious Soviet world Chess champion, spoke to the two men about his recent world chess match held in Baguio. Kovalyonok showed Karpov a chess board onboard the space-station on which the pieces were arranged exactly as in the winning game at Baguio.

On 30 October, the cosmonauts devoted a lot of time to transferring films, flight documentation, and research materials to the descent module of Soyuz 31. Used equipment was also stowed in the orbital module, and Salyut 6 was prepared for automatic flight. Again, a large part of the day was devoted to medical research and experiments, including the reaction of the cosmonauts cardio-vascular systems to conditions of simulated hydro-static pressure using Chibis. Exercises on the velo-ergometer and running track had been stepped up. In addition, as weightlessness always entails a considerable loss of fluid – a form of dehydration of the body – the cosmonauts had started to consume large amounts of salinated water to correct their fluid deficiency which would become more apparent on Earth. They had also been taking supplementary concentrated food rations.

Biological Experiments

Galina Semerova, an adviser to the crew on biological experiments, said that Yuri Romanenko and Georgi Grechko had carried out more genetic and embryological experiments on micro-organisms while the tasks of the present crew were somewhat different. The men had carried out many experiments with plants and fungi while continuing the genetic and embryological ones. Two types of plants were used. One was a very small plant, the whole development cycle of which could be observed in conditions of weightlessness over approximately one month. The first results of this experiment had been obtained, and although the plant developed more slowly in weightlessness, the results were very interesting in that it was not possible to on-obtain a second-generation in space. It is thought that the plant had just reached its most complex stage approaching the stage of fruit bearing. The onion plants, on the other hand, had grown seedstalks. This was unexpected, since on Earth, onions do not produce seeds in so short a period. These principles of plant growth can be used to select a model for use in life-support systems so that cosmonauts can grow their own onions and other vegetables onboard the space station.

Another interesting experiment had been carried out with fungi. Fungi have a very good geotropic reaction, meaning that they react to gravity, and it was observed that during the experiment, the fruit bodies formed by the fungi were absolutely disorientated. The aim of the experiment was to study the mechanics of the effects of gravitation. It proved that gravity could be replaced by a light source and that plants would grow towards the light.

Cosmonauts Return

On 1 November, Radio Moscow reported that the crew would be returning to Earth on the following day. On 2 November, the men transferred to Soyuz 31, and closed the hatch at 04.35, undocking at 07.46 and 0.4 seconds. The braking engine was fired for 0.3 seconds at 10.15 and 17.3 seconds over the Atlantic, reducing the speed of the descent module by 15 m/sec. Separation of the modules took place over Africa, a little north of the Equator.

The capsule touched down at 11.05, 180 km (112 miles) south east of Dzhezkazgan, Kazakhstan, approximately 514 km (320 miles) east of Tyuratam/Leninsk. The record-breaking mission had lasted 139 days, 14 hours and 48 minutes. Soviet TV gave live coverage to the landing operation, and viewers watched Vladimir Kovalyonok and Alexander Ivanchenkov walk completely unaided from the descent module.

On the spot medical checks were carried out, and the men were said to be in good condition. Kovalyonok had lost 2.3 kg (1.0 lb) in weight, and Ivanchenkov 3.9 kg (1.8 lb). The girth of the hip of the commander had diminished by about 1.5 cm, and that of Ivanchenkov by about 4 cm. Kovalyonok said he felt alright, "but when I try to move my head, I feel its weight. The body has to become adapted to Earth conditions, but it's alright. There will be even longer space flights," he said confidently. Ivanchenkov said "We are happy to feel again the Earth's gravity. We are looking forward to a reunion with our relatives and friends. The flight programme has been fulfilled and we obtained interesting scientific material."

Onboard the plane which took them back to Tyuratam/Leninsk, (after a launch-to-return round trip of approximately 90,000,000 km (55,926,000 miles), the men sat down at a table laid with tomatoes, bread and grapes. Kovalyonok however, was only allowed a cup of hot tea which, according to the doctors, was "enough for the present."

In a report from MCC issued a few days before the touch-down, it was revealed that the long flight had apparently given the cosmonauts amazing powers of sight. On one occasion, they were flying at a height of about 290 km (180 miles) but were able to distinguish a depression only about 20-30 m wide in a glacier. In another experiment, they reported that a glacier was 200 m (219 yards) from a specified point, and when scientists checked this, they found that the cosmonauts were correct to within a few metres.

On 3 November, when the cosmonauts awoke, doctors allowed them to test their strength by letting them do squatting, bending and walking exercises in their room. In order to get accustomed more quickly to an upright position, they were told to wear special training trousers which made it easier for the leg vessels to adapt themselves gradually to being filled with blood on Earth. The doctors were predicting that it would take 10-15 days for the cosmonauts to re-adapt to Earth conditions.

Anatoli Vasilyevich Beregovki, leader of the medical group at Tyuratam/Leninsk, said "The condition of the crew is entirely satisfactory. But it must be said that all the expected manifestations that weightlessness produces in the course of a long flight have occurred. And, let us say, the co-ordination of movements was affected; there were vestibular effects....some reduction of physical loads – all this has been noted."

"The condition of the crew is in some ways slightly better than was that of the crew who spent 96 days in orbit. We must pay great attention to this period since re-adaptation to terrestrial conditions....represents a heavier load than adaptation to the conditions of weightlessness." During the day, as well as undergoing medical check-ups, the cosmonauts attended a press conference. "It was not easy for me after I had left the ship," said Vladimir Kovalyonok, "to bend and pick up a small lump of Earth because of the gravity, but I forced myself to do it, and the smell of the sun-drenched Steppe will remain with me forever."

Alexander Ivanchenkov said that "several minutes before our landing, when the ventilation holes opened, wind rushed into our cabin. Forgetting about the belts which tightly held us to the chairs, we both leant forward towards the Earth's air. Later, when we stepped on the ground, we were literally intoxicated by the fresh wind."

Post-flight Rehabilitation

On 4 November, the two men underwent a second day of medical checks and were allowed a short walk in the park around the "Hotel Cosmonaut". Accompanied by doctors they walked 1,400 steps, following which their pulse was only 15-20 beats faster, and both felt fine. The walk lasted 40 minutes. They received congratulations on their success-

ful mission from Sigmund Jähn, Miroslaw Hermaszewski, Vladimir Remek and from American astronauts.

On 5 November, instead of having their meals brought to them in bed, the cosmonauts were allowed to go to the canteen to get them. The greater part of the day was again taken up by medical examinations. Doctors reported that the mens' readaptation was proceeding at a faster rate than the previous crew had experienced.

On 6 November, a Washington source reported that the cosmonauts were residing in a new Scientific Rehabilitation Centre at Tyuratam for a month, and would then possibly transfer to a health spa for an additional month before making any public appearances.

On 12 November, the cosmonauts were reported as saying that they were in favour of still longer expeditions in orbit. Longer flights, they argued, stimulate working ability, and as a result, make research in space more effective. On 13 November, the two men prepared to leave Tyuratam/Leninsk to return to the Cosmonauts Training Centre in Star Town. *Tass* reported that it had only taken the men 10 days to readapt to 1 g.

On 14 November, Kovalyonok and Ivanchenkov flew into an airfield outside Moscow, to a welcome by relatives, scientists, designers, flight controllers, journalists and fellow cosmonauts, including Hermaszewski and Jahn. The men were then taken to Star Town, and Radio Moscow reported that Kovalyonok and Ivanchenkov would be going to a holiday centre in the Northern Caucasus to rest and to work on their full flight report.

On 15 November, the cosmonauts went to Moscow to receive their Gold Star medals and Orders of Lenin that accompanied their awards of the title Hero of the Soviet Union. Presenting the men with their prizes, Brezhnev said, [in part], "Dear comrades, the successful carrying out of the longest spaceflight in history, the flight of the Salyut 6–Soyuz complex, known throughout the world, is a mighty victory for Soviet science and technology, knowledge and skill, will and heroism of the Soviet party . . . To live for a long time in space in such unusual conditions is quite a feat, but to work in space—and to work with such devotion as comrades Kovalyonok and Ivanchenkov—is a double feat. The things they had to do! They were metallurgists, astronomers, geophysicists, and geologists. They showed themselves to be excellent specialists in different branches of science, technology and economics. That is the job of cosmonauts . . . Comrades Kovalyonok and Ivanchenkov carried out their spaceflight brilliantly."

Moscow Press Conference

On 16 November, a press conference was held in the lecture hall of Moscow University; taking part were Kovalyonok, Ivanchenkov, Hermaszewski, Jahn, Beregovoi, Leonov, Yeliseyev, Feoktistov, Academicians Gazenko, Petrov, Sagdayev, and Logunov, together with flight controllers and others. The conference was opened by Academician Anatoli Alexandrov, President of the Soviet Academy of Sciences.

In reply to questions, the cosmonauts said that their favourite food on Salyut 6 was curd with strawberries. Asked if they had any animals onboard, they said they had one—a hairy toy bear, the symbol of the 1980 Moscow Olympics.

Feoktistov reported that the Salyut was shortly to be checked for its technical and operational fitness. This checking would take several months, and the results of the study would make it possible to determine the feasibility of the station's further use. Boris Petrov, Chairman of the Intercosmos Council, stated that there were definite plans to stage new flights by international crews in 1979.

In a speech, Academician Gazenko gave a detailed insight into the medical studies carried out during the record flight. "Throughout the flight," he said, "periodically—as you probably know from press reports—detailed medical research was carried out on specially appointed days. This research was carried out both when the cosmonauts were in a state of rest or, so to speak, relative rest, and when various tests under stress were being carried out. Well, I should like to say that the cosmonauts were exceptionally sensible and creative in carrying out that great and, of course, not always pleasant work. If you think about it, the men there took samples of their own blood and carried out biochemical research, which is not always a pleasant thing to do, but nonetheless they carried it all out. They co-operated well with the ground staff, constantly showed a great interest in discussing the data obtained, and made constructive proposals for carrying out further research.

The detailed and sufficiently frequent electrocardiographic research conducted during the flight did not show any deviations from the norm throughout the flight. Functional tests at dosed physical stresses and also with the application of negative pressure to the lower part of the body also showed that these reactions were adequate and, most important, that no negative dynamic was noted. With the passage of time, the responses to these tests did worsen. The objective signs of redistribution of the blood, as revealed by such a method as rheography, were observed with particular accuity during the initial phase of the flight. It was possible to register these signs in the overfilling of the vessels of the head and upper part of the body and the depletion of the blood vessels in the lower part of the body, particularly in the legs. These readings averaged out somewhat in the middle stages of the flight, but all the same persisted to the end, although, as the cosmonauts will relate, this did not cause them any unpleasant sensations.

As they became adjusted to weightlessness, a new coordination of motion naturally became established, which provided sufficient efficiency for the fulfilment of all necessary operations. An analysis which was conducted of the television images observed on Earth indicated that comparatively soon, at least by the end of the first month, these movements were being carried out rapidly, precisely, and with confidence. At the same time, with the passage of time, a reduction in the volume of the lower limbs was registered, in particular the crus*, which as is known, indicated the loss of a certain part of the fluid component, so to speak of the lower limbs and partly of the muscle tissue."

On 12 December, Gazenko reported in an article in *Kosomolskaya Pravda* that Kovalyonok and Ivanchenkov were now as healthy as before their 140 day flight. They had lost some of their muscular mass, but this had been fully regained. They returned to Earth with red blood cells that had developed in space which were smaller than usual. However, these cells coped fully with the supply of oxygen to the tissues. Dr. Gazenko believed that these cells would eventually die and be replaced by new ones which would be of the kind the cosmonauts had before their flight.

On 29 December, Salyut 6 completed its 15 month in orbit.

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* *That part of the leg between the knee and the ankle.*

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Informal Talk
Title: **AN EVENING WITH ARTHUR C. CLARKE**
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.I. on **28 August 1979**, 7.00-9.00 p.m.

Admission tickets are not required, Members may introduce guests.

3rd BIS CONFERENCE ON INTERSTELLAR STUDIES
The Conference will be held in the Chemistry Lecture Theatre, University College, London, W.C.I. on **11-12 September 1979.**

Applications for registration forms and notifications of the intention to submit a paper for the Conference should be made to the Executive Secretary of the Society.

34th ANNUAL GENERAL MEETING
The 34th Annual General Meeting of the Society will be held in the Tudor Room, Caxton Hall, Caxton Street, London, S.W.1. on **13 September 1976,** 7.00 p.m.

A detailed Agenda appears on page 325 of the July issue of *Spaceflight.*

30th IAF Congress
The 30th Congress of the International Astronautical Federation will be held in the Deutsches Museum, Munich, Germany, from **17-22 September 1979.**

Theme: **SPACE DEVELOPMENTS FOR THE FUTURE OF MANKIND**

Details of the technical sessions were listed on page 176 of the April issue of *Spaceflight.* Members wishing to present papers and requiring further information are asked to contact the Executive Secretary.

A particular invitation has been extended for papers to be presented at the Student Sessions of the Congress: these must be submitted through an IAF Member-Society.

BIS members, both from the U.K. and overseas, who plan to attend the Congress are asked to notify the Executive Secretary accordingly.

Lecture
Title: **BEYOND SATURN** by Dr. G.E. Hunt.
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.I. on **9 October 1979**, 7.00-9.00 pm.

Admission tickets are not required, Members may introduce guests.

3rd Computers & Space Technology Conference
Theme: **IMAGE PROCESSING TECHNIQUES APPLIED TO ASTRONOMY AND SPACE RESEARCH**

To be held at the SRC Appleton Laboratory, Ditton Park, Slough, Bucks, on **15-16 November 1979.**

Topics will include:

a) Astronomical Image Processing

b) Planetary Imaging

c) Remote Sensing

d) Interactive Processing and System Design

e) Application of Array Processors

f) Image Restoration

Offers of papers (including a 300-500 word abstract of the proposed paper) should be sent to the BIS Executive Secretary, 27/29 South Lambeth Road, London SW8 1SZ, England.

Lecture
Title: **THE INTERNATIONAL SOLAR POLAR MISSION**
by D. Eaton (ISPM Project Manager)
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.I. on **21 November 1979**, 7.00-9.00 p.m.

Admission tickets are not required. Members may introduce guests.

STUDY COURSE

THEME: **THE ORIGIN AND EVOLUTION OF THE UNIVERSE**

A course of seven evening lectures will be given on the above topic during the 1979/80 session. Details are as follows:

Chairman: A. T. Lawton

3 October 1979	The Primordial Fire Ball by Dr. I. Robson
7 November 1979	Quasars and Seyfert Galaxies by Dr. R. F. Carswell
5 December 1979	The Extragalactic Distance Scale by Dr. D. A. Hanes
2 January 1980	The Evolution of Stellar Systems by Dr. J. Jones
23 January 1980	X-Rays in the Universe by Dr. A. C. Fabian
20 February 1980	Future Observations in Cosmology by Dr. C. D. Mackay
5 March 1980 (provisional)	The Microwave Background: Relic of the Big Bang? by Dr. M. Rowan-Robinson

Course fee: **£5.**

The Venue will be the Golovine Conference Room at the Society's Headquarters, 27/29 South Lambeth Road, London, SW8 1SZ, England.

For further details and application forms apply to the Executive Secretary of the Society

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SALYUT 6 MANOEUVRES

By A.J. Driver and G.E. Perry, Kettering Group

The Salyut 6 mission has utilised a stabilised ground-track which repeats itself on alternate days after 31 revolutions. This is achieved by a suitable choice of orbital period for a circular orbit at the given inclination of 51.6° which takes into account the 5°/day precession of the orbital plane due to the equatorial bulge. A circular orbit at 350 km with a nodal period of 91.37 min satisfies these conditions.

Such an orbit provides launch-windows for rendezvous with the space station at two-day intervals. The longitude of the ascending node on launchday depends on the type of rendezvous undertaken. The pursuing spacecraft is launched at the instant the launch-site lies directly in the orbital plane of the space station. This implies that, if the space station is to be ahead at this time, it will cross the latitude of the launch-site some way to the east. For a Soyuz, with a one-day rendezvous, Salyut has an ascending node at 341.2°. An unmanned Progress supply ship, with a two-day rendezvous, has an ascending node even further east at 337.7°.

Manoeuvres to the 91.37 min period and the location of the stabilised ground-tracks provide clues to the imminence and nature of forthcoming missions. Fig. 1 is a plot of mean-motion, and the related anomalistic period, against calendar date. Major manoeuvres during the first two long-duration missions are described below.

1. An intermediate burn four days after launch raised apogee to 350 km, prior to circularisation, producing a period of 90.25 min.
2. Four days later the orbit was circularised by raising the perigee in readiness for the launch of Soyuz 25. Following the failure of Soyuz 25 to achieve a hard-docking and its return to Earth, the orbit decayed naturally.
3. Perigee was turned into apogee to stabilise the ground-track in readiness for the launch of Soyuz 26. This was followed by minor burns to correct the ground-track prior to the launch of Soyuz 27 and Progress 1.

3a. The Progress 1 engine burned for 67 s to change the inclination by 2.5′ to 3′ with a Δv of 8 m/s.

4. Perigee turned into apogee with relocation of perigee prior to the launch of Soyuz 28. The next two minor burns are of special interest. Each occurred immediately before the landings of Soyuz 28 and Soyuz 27 as tests of the Soyuz engine. That one raised the orbit and the other lowered it can be explained by the fact that the two spacecraft were docked at opposite ends of the space station.
5. Perigee turned into apogee by a burn with Δv of 15.2 m/s to arrest natural decay whilst unmanned.
6. Perigee turned into apogee in readiness for launch of Soyuz 29.
7. Apogee lowered in what was announced as a "routine orbital correction".
8. Apogee raised prior to the launch of Progress 3.
9. Orbital correction using the Progress 3 engine.
10. Apogee raised in readiness for launch of Soyuz 31.
11. Apogee raised prior to launch of Progress 4.

12a. Progress 4 engine used to raise apogee.

12b. Progress 4 used again on following day to raise perigee to circularise the orbit prior to the unmanned phase in the automatic mode following the return to Earth of the record-breaking crew in Soyuz 31. The resulting high orbit suggested a prolonged period of unmanned flight. By mid-February, 1979, the orbital period had decayed to 90.5 min.

The authors wish to thank the Goddard SFC for providing orbital elements, the BBC Monitoring Service for providing transcripts of Russian news broadcasts, and Mark Simms for calculating the apogee and perigee heights.

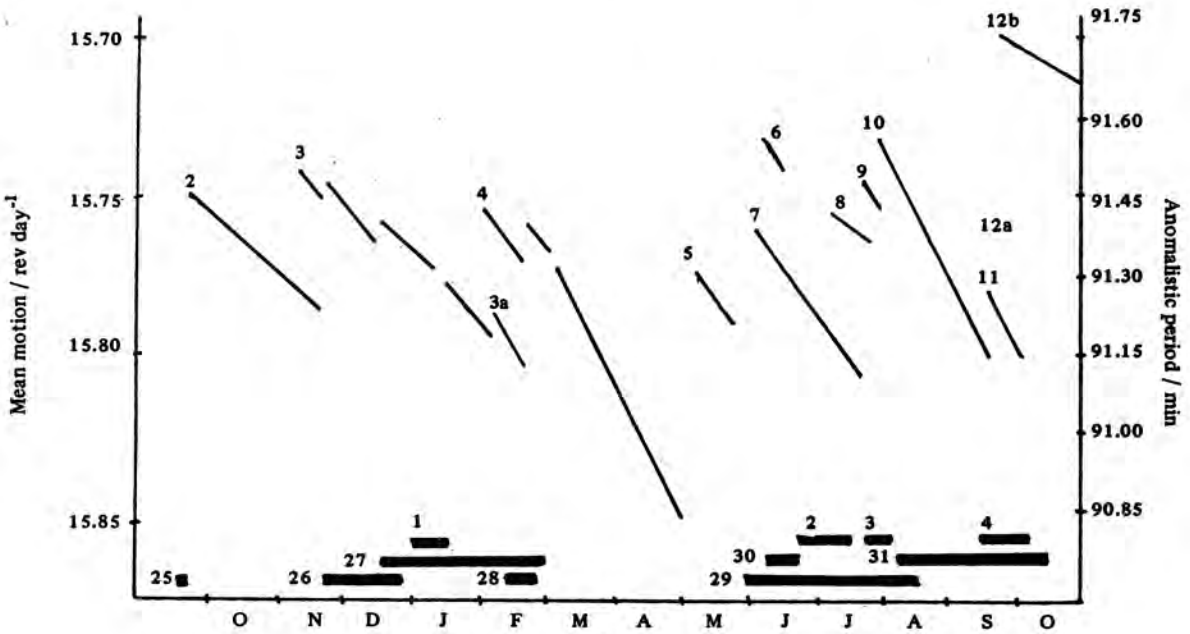


Fig. 1. Salyut 6 manoeuvres. Horizontal bars show relative dates of Soyuz and Progress missions.

SPACE REPORT

A regular monthly review of Space Events and Technical Trends

SOLAR POLAR MISSION

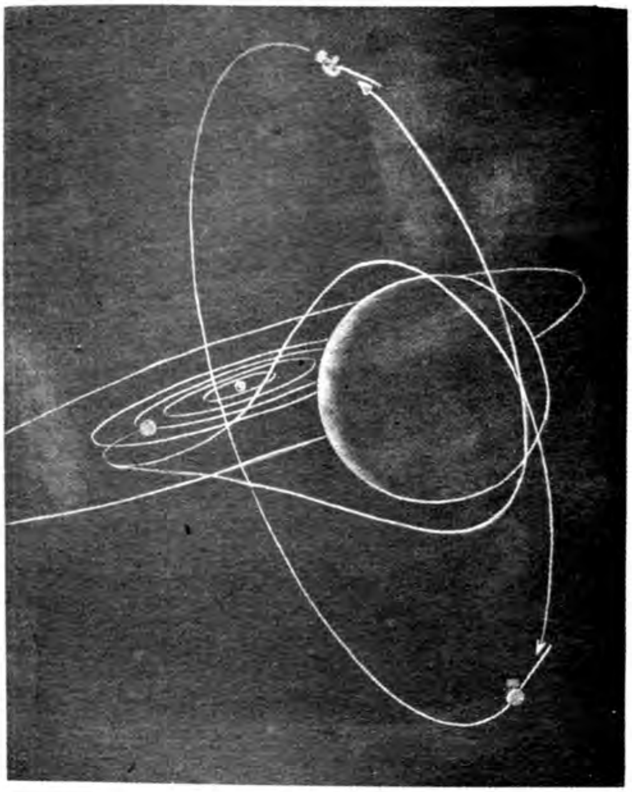
NASA and the European Space Agency (ESA) have signed an agreement for a joint International Solar Polar Mission (ISPM) to be launched in 1983. The two-spacecraft mission will observe the Sun for the first time from above its polar regions.

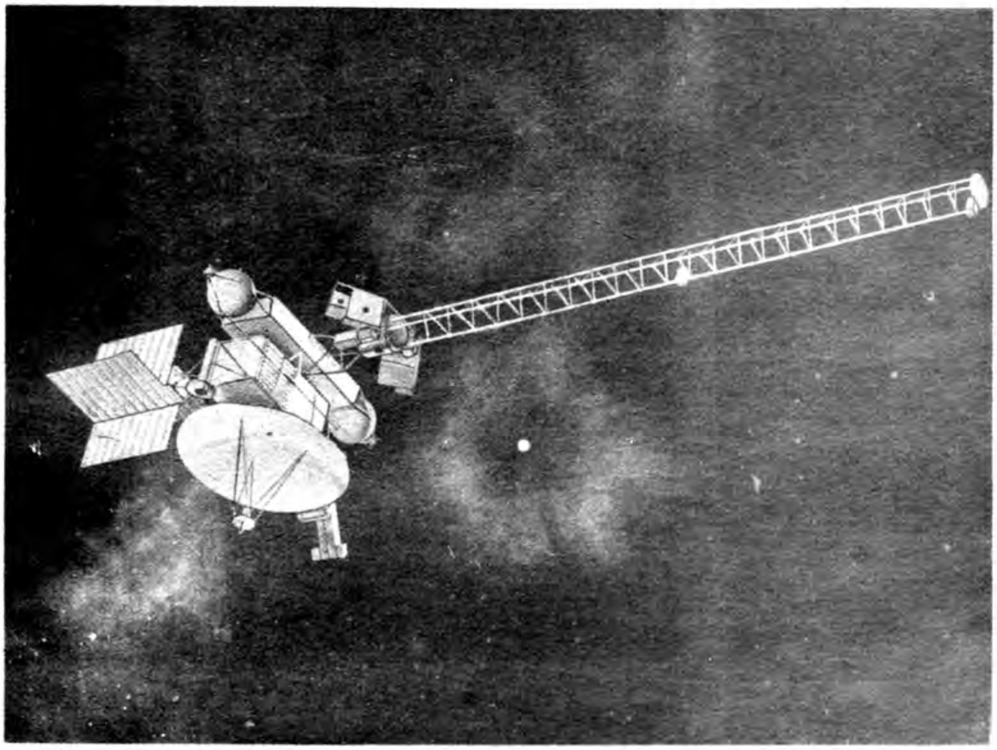
The primary objectives of ISPM are to extend scientific knowledge and understanding through exploration of the Sun and its environment by studying the Sun's structure and emission as a function of latitude from the solar equator to the solar poles. Secondary mission objectives are to investigate the interplanetary medium during the initial Earth-to-Jupiter travel and the Jovian magnetosphere as the spacecraft fly by Jupiter and are deflected by its gravity to their solar trajectories.

Under the agreement, NASA and the 11-member ESA will each provide a spacecraft. ESA also will supply the software and personnel to manage and support ESA flight operations and data processing at the U.S. facility. In addition to ESA's participation, the Federal Republic of Germany, the United Kingdom, France and Switzerland will provide mission experiments.

NASA also is responsible for: one partial and five complete science experiments for the ESA spacecraft; launch operations services and launching of both spacecraft by the Space Transportation System; Tracking and Data Acquisition (TDA) for Earth-orbital checkout of both spacecraft and TDA from deep space; a mission control and computing facility and appropriate data records to scientific and engineering personnel.

Both spacecraft will be launched simultaneously by the Space Shuttle and then directed on a trajectory in the ecliptic plane (the plane which contains all of the planets) to Jupiter by an Inertial Upper Stage booster.





PROBING OUR HOME STAR. This painting shows the trajectories of the two Solar Polar spacecraft. After launch from an orbiting Space Shuttle, the two unmanned craft will fly out to Jupiter and use the giant planet's gravity to slingshot them out of the ecliptic plane and back toward the Sun.

Left, one of the two proposed spacecraft if shown in this painting as it draws near the Sun. The double mission is intended to study the Sun's polar regions and the interplanetary environment near them – where no spacecraft have gone before. The mission, to be flown in 1983, is being jointly organised by NASA and the European Space Agency. Project manager is the Jet Propulsion Laboratory, Pasadena, California.

National Aeronautics and Space Administration, JPL

The two spacecraft will swing around Jupiter and use the gravity of that giant planet to redirect their paths out of the ecliptic plane back toward the Sun in trajectories – one northbound and one southbound – that are essentially mirror images of each other.

They will pass over the north and south solar poles, swing back through the ecliptic plane, pass respectively over the other solar poles and then fly back out to the vicinity of Jupiter's orbit. The period from launch until shortly after the second pair of solar passages is approximately five years.

EXTREMELY DISTANT QUASARS

Scientists analysing more than 500 images received from NASA's High Energy Astronomy Observatory 2 (HEAO-2) have seen the brightest, most distant and most powerful objects yet observed to emit X-rays: quasars estimated to be more than 10,000 million light years from Earth.

The intense X-ray emission from the quasars, strange star-like objects that radiate inordinate amounts of energy for their apparently small size, suggests that they may contribute significantly to the widespread low-level background of cosmic X-ray radiation detected throughout the skies.

The discovery could have important implications for theories of cosmic evolution, for it would mean that the proposed mass necessary to "close" the Universe is not present in the form of hot gas and, indeed, may be missing. The finding lends support to theories that the Universe may expand forever.

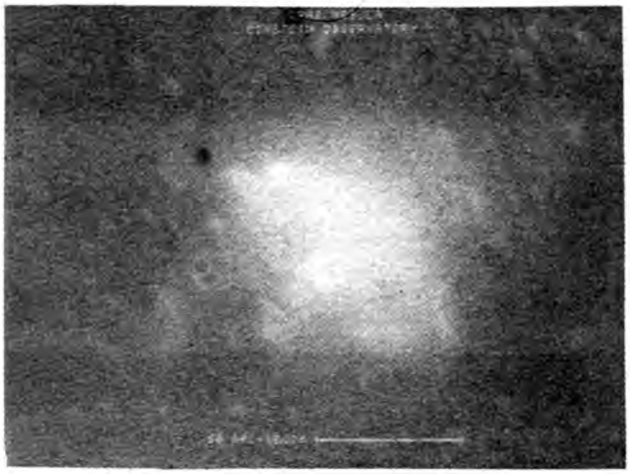
HEAO-2, nicknamed "Einstein Observatory" after its launch on 13 November 1978, is the second in a series of satellites designed to survey the sky in X-rays, an energetic form of radiation which is associated with some of the most powerful activity in space and yet is invisible to ground-based observers, having been absorbed by the Earth's atmosphere.

Einstein carries the first telescope capable of producing focused images showing the structure of X-ray objects. Previous experiments could only detect the approximate position and intensity of objects.

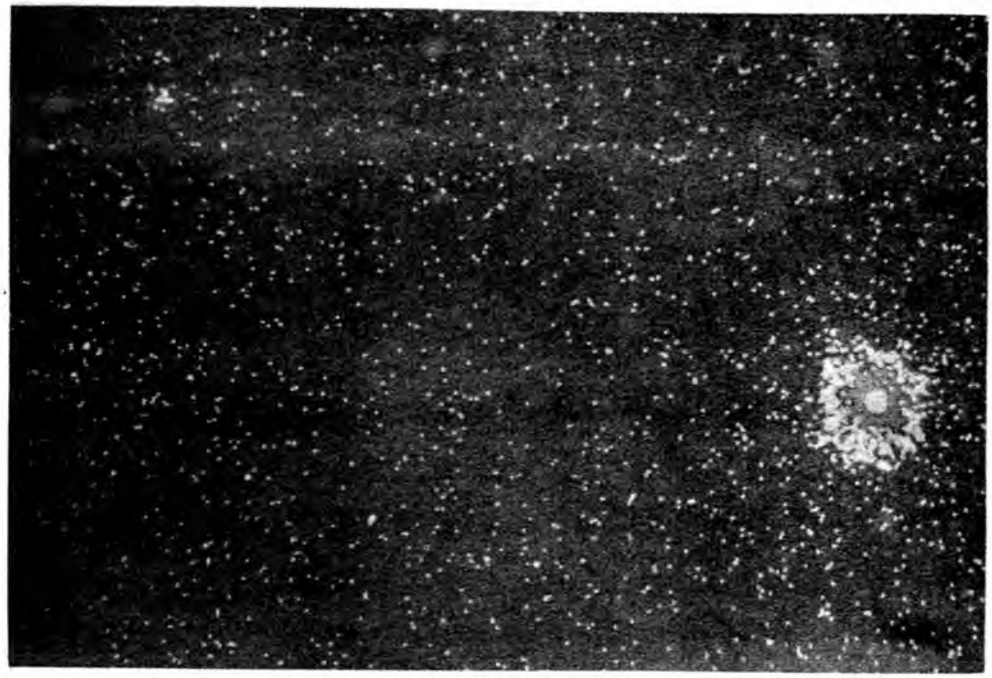
The distant quasars were discovered by scientists of the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts, using HEAO's high-resolution telescope in its so-called 'serendipity mode' to make deep space surveys.

The objects appeared as bright point sources in otherwise featureless fields and, when compared with optical charts of the same sky regions, corresponded with extremely faint visual objects later identified as quasars by observations of their red shifts made by astronomers using the ground-based four-metre (13 ft) Anglo-Australian telescope. Several of the objects had not previously been identified as quasars.

The most distant quasar detected through optical means is about 15,500 million light years away. But with HEAO, scientists now believe they have the telescope sensitivity to detect quasars which are even more distant, or to determine that quasars more distant than 15,500 million light years do not exist.



CRAB NEBULA. This X-ray picture taken by HEAO 2 shows the Crab Nebula, remnant of a supernovae first observed by Chinese astronomers in 1054 A.D. The bright object in the centre is a pulsating star (pulsar) that spins 30 times per second and emits regular signals, once per revolution. The X-ray emission directly above the pulsar is the result of radiation from very high energy electrons in a weak magnetic field. The HEAO 2 picture reveals a very complex transfer of energy from the pulsar to the surrounding medium.



NEW QUASAR. This X-ray picture obtained by HEAO 2 reveals a newly discovered object (upper left) which appears to be the most distant and brightest quasar yet observed to emit X-rays. Its Red Shift of 2-2.6 indicates that the light reaching us began its journey more than 10,000 million years ago. The bright object (lower right) is quasar 2G273, a familiar object to astronomers since its discovery a decade and a half ago.

National Aeronautics and Space Administration

ANDROMEDA. This is an X-ray image of the central region of M-31, the Andromeda galaxy, taken by HEAO 2. At one and a half million light years, M-31 has the distinction of being the most distant object visible to the naked eye. Twenty X-ray sources are discernible in this image. In the galaxy as a whole, HEAO 2 has detected about 60 sources. The orientation of this group of 20 sources in the central region does not coincide with the plane of the galaxy. This is surprising, since most X-ray sources in our Galaxy are in the galactic plane.

YOUNG STARS. This X-ray picture by HEAO 2 shows several distinct young stars superimposed on a region of lower-intensity X-ray emission. Further study of this region is expected to provide a better understanding of the process by which stars are formed. The young stars represented here were not known to emit X-rays at such an early stage of development.

National Aeronautics and Space Administration

MAKING HIGH-PURITY GLASS

Soviet scientists have been encouraged by the success of the experiment in which the second crew of Salyut 6 melted optical glass. Speaking of the results, Gury Petrovsky, a corresponding member of the USSR Academy of Sciences who helped to develop the experiment, explains that the research effort has tremendous importance for optical communications (fibre optics).

A 'light guide' of one micron thickness one kilometre in length weighs only one to two grammes yet it can carry a thousand times more information than a normal telephone wire. But such capacity requires glass in which only one gramme of impurities occur in 10 tonnes. It is possible to achieve a glass of this purity only in space where the melt does not contact the walls of the crucible.

Soviet scientsits visualise orbital factories in which glass will be melted without a crucible—the melt will be suspended in weightlessness; and then we shall form precise optical parts out of it, Petrovsky says. "But all this is a matter of the future. Today we need to check our suppositions and conduct experiments: the simplest ones so far."

Glasses of different types were made on board Salyut 6. For example, "we wondered how the gases contained in the melt would behave, and whether we should get a certain foamed mass instead of glass. That did not occur—the gases concentrated in some zones (and the knowledge of this is very important to us)."

"The space experiments showed that the glass melt makes far less contact with the walls of the crucible; and the glass so obtained is much purer than glass made by conventional methods on Earth."

COSMOS 315 FALLS OVER CANADA

In the late hours of 24 March, 1979, Cosmos 315 made a fiery re-entry over five American states and apparently burned out high over the Canadian Northwest Territories. In contrast to the furor that ensued in the wake of the nuclear-powered Cosmos 954 the latest incident barely caused a stir in government circles in Ottawa, writes Gerald L. Borrowman.

Cosmos 315 was launched from Plesesk on 20 December, 1969, by a C-1 booster at an inclination of 95.3 degrees. The weight was estimated at 556 kg and while conventionally powered it was thought to be a ferret satellite.

A North American Air Defence (NORAD) spokesman reported that Cosmos 315 apparently burned up before striking the surface in an area of lakes west of Hudson Bay. Several days after the incident a NORAD spokesman again explained that space satellites, boosters or debris plunge into the atmosphere at a rate of more than one a day.

SPACE HISTORIES

Two histories of major space achievement have been published by the National Aeronautics and Space Administration.

One is the official NASA history of the international cooperative effort of two spacefaring nations and their collaborative mission to rendezvous and dock manned spacecraft in Earth orbit. The other is a publication in the NASA history series that describes the Apollo launch facilities at the Kennedy Space Centre, Florida.

Both publications may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, by specifying:

The Partnership: A History of the Apollo-Soyuz Test Project (NASA SP-4209), by Edward Clinton Ezell and Linda Neuman Ezell. Paperbound. 580 pp. Price $8.30 plus postage.

Moonport: A History of Apollo Launch Facilities and Operations (NASA SP-4204), by Charles D. Benson and William Barnaby Faherty. Paperbound. 656 pp. Price $8.00 plus postage.

SPACE SUIT MONITOR

The Harris 6100 12-bit CMOS microprocessor has been chosen as the central controller for the space suits to be worn by astronauts in the forthcoming Space Shuttle Programme. The micro-controller will provide full monitoring of space suit and astronaut conditions, this information being continuously updated and displayed on an indicator panel worn on the astronaut's chest.

In addition, the micro-controlled system will provide a navigation and propulsion capability and allow the astronauts to leave the spacecraft without the cumbersome 'umbilical cord'.

SOVIET SPACE ENCYCLOPAEDIA

An *Encyclopaedia of Cosmonautics* is to be published in Moscow next year. Edited by the veteran rocket engine designer, V.P. Glushko, it will contain more than 3,000 separate articles and nearly 1,000 photographs.

There will be 14 chapters including Rockets and Space Vehicles, Engines and Propellants, Cosmodromes, Space Biology and Medicine. Experts on space rocketry, many of whom were themselves pioneers in the field, contribute to the text. Biographies will be included of all cosmonauts.

The encyclopaedia, "for the first time, includes information about space vehicles and programmes of all states participating in space." Special attention is being given to international cooperation.

LASER HEAT ENGINE

An engine powered by the expansion of air heated by a laser beam is being developed by Soviet scientists. As the working fluid is used over and over again, there is no pollution of the atmosphere. Work is centred at the Lebedev Institute of Physics.

THE COST OF APOLLO

The peak annual cost of the Apollo project was less than what Americans spend on luxury items, according to the Apollo 17 commander.

Eugene Cernan, in the annual report of Rockwell International, wrote that the entire space programme cost only $30 per citizen in 1966, and now costs only $17 per citizen.

"When we consider that at the same time each of us in this country spent something like $130 a year on such items as alcohol, tobacco, and cosmetics," Cernan wrote, "and spent as much as $22 a year to feed the cat and the dog—an and I'm not saying that any of these items might not be personal necessities—I truly believe that most people would willingly support the $17 per person spent on space today, looking upon it as an investment in the future of America."

Cernan is now an executive vice president of Coral Petroleum Company. Rockwell is prime contractor for the Space Shuttle, and built the Apollo command/service modules and Saturn rocket engines.

FRUSTRATIONS AT THE CAPE

Launch date for the Columbia slipped as work fell about a week behind early in April. The reason for the delay was because of problems connected with dummy foam tiles which were installed to give the Orbiter aerodynamic stability for the long trip. Scratches were found on the frame of the Columbia where the adhesive (RTV) had been placed to hold the foam tiles in place. Cleaning up those areas for the installation of the permanent tiles required longer than had been expected, writes Gerald L. Borrowman.

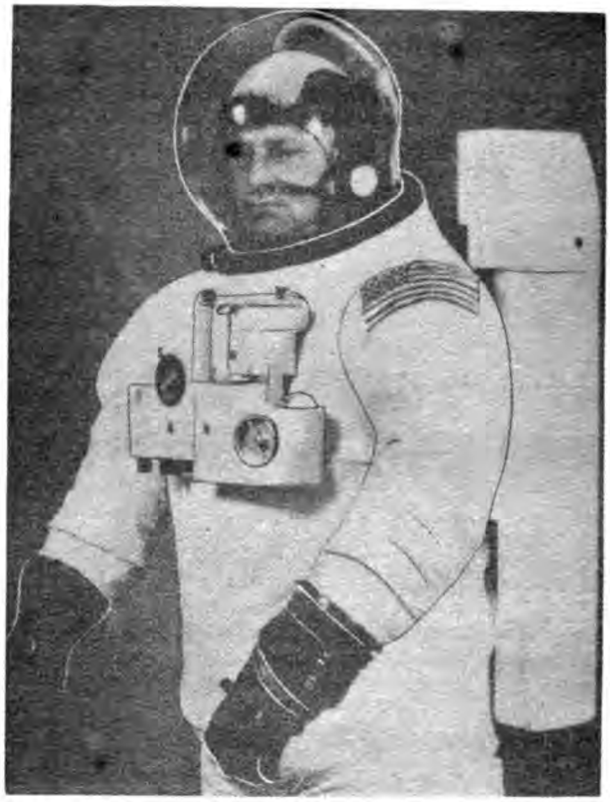
Also the adhesive had spread out and come in contact with the sides of some of the permanent thermal protection tiles. This necessitated removal of the adhesive from the permanent tiles.

On Monday 9 April astronaut trainee Francis Dick Scobee and later astronaut Karol Bobko entered Columbia's cockpit. (The previous week Bobko and astronaut candidate Loren J. Shriver had checked out various systems). The tests with the astronauts aboard the Orbiter involve powering up various systems. Monday's troubleshooting centred around a printed circuit card which was part of the ground support equipment in the launch check system.

Astronauts John Young and Bob Crippen unveiled the insignia for their mission aboard Columbia. The patch depicts a Space Shuttle blasting off with an Orbiter circling the globe, and will be the official crew emblem for the flight.

At 2:53 p.m. on 10 April the Enterprise arrived at the Kennedy Space Center. Pilot Joseph Algranti landed the Enterprise-747 jumbo-jet combination after two "touch and go" test landings. The opportunity afforded pilots Fitzhugh and Ken Haughton to practise landings with the Orbiter. The 2½ hour flight from the Marshall Space Flight Center was moved ahead by three hours in order to beat a thunderstorm across Central Florida.

After the demating process Enterprise was left on the landing strip over the weekend to afford the public an opportunity to view the spacecraft.



A Shuttle astronaut with the new monitoring, navigation and propulsion system controlled by a Harris 6100 12-bit CMOS microprocessor.

Consort PR

Meanwhile in Washington, D.C., Senator Proxmire, outlined his objections and doubts about America's space programme. When questioned about his opposition to the Shuttle he replied:

"Well, the principal problem we have with space is that we have a limited federal budget and limited federal resources. If it were something that didn't cost anything, it would be fine, if it were something that was being done by some agency other than the federal government. But here we are, running an enormous deficit. We're suffering from inflation and federal spending is a very, very serious problem. It's extremely difficult to cut federal spending anywhere.

"The space programme, although a very valuable programme and one which I think 1,000 or 10,000 years from now – if mankind is still inhabiting the planet – they they'll bless us for, nevertheless is a programme that, by and large, can be postponed. Many of its benefits are out in the distant future.

"The problem we had with the Shuttle is that we wanted to be sure the Shuttle was the most efficient and effective and inexpensive way to achieve their ends. In the process of determining that, we get testimony from various groups, including the Defense Department. We asked them (defense officials), if they were required to pay the full cost of the portion of the Shuttle they would use, whether they would put it on their budget, and they said no, it would have too low a priority."

When asked if the general public would approve a substantial cut in space programmes, Proxmire replied that he did not think the American people would want to eliminate the space programme by any means. Much of the space programme in his estimation could and should continue. He expressed the desire to hold down the increases everywhere, including the space programme. He continued to state that the point of no return had been passed in the Shuttle programme, but he saw no need for a fifth Orbiter.

The same day a one-page NASA report on why permanent and dummy tiles on Columbia had been damaged or destroyed was released. However it failed to satisfy Rep. Bill Nelson who called for an investigation. The report spoke only of the design and installation of the permanent tiles which remained intact during the test flight.

The report said, "Although real tiles were damaged, there is no question about the integrity of the TPS (Thermal Protection System) design or installation techniques."

The report said seven permanent tiles were destroyed, 100 of the permanent units were damaged, 34 dummy tiles lost and an additional 39 damaged during the test flight.

The question remained unanswered as to why NASA did not wait to move the Orbiter until after all the permanent tiles were in place and why Columbia wasn't shipped minus all tiles and then have them installed at the KSC.

A network of microscopic cracks were detected in the welded joints of the mobile launch platform. The discovery was made after several welding deficiencies were found in a launching platform scheduled for use in later launches. The project engineer for the Shuttle launch complex stressed that the cracks, discovered among the dozens of welds that join various parts of the mobile launcher, constitute no threat to the platform's stability for a launch. The cracks probably resulted from routine heating stress applied during the welding process.

Modifications to the launch platform to modify it for the Orbiter include steel plating, from one to two inches thick, to insure the deck can withstand the intense heat of the engines of the Orbiter. Although holes in the platform will channel the rocket blast into a flame trench the rocket engines' flames will be deflected toward the deck of the launcher.

Tuesday, 24 April, the Enterprise was hoisted into a vertical position so it could be mated to other key Space Transportation System elements. The procedure was delayed by an hour when some hydraulic fluid leaked out of the Enterprise after its rear landing wheels were raised. The hoisting of Enterprise onto the mobile launcher platform took only 20 minutes.

Meanwhile NASA Associate Administrator for space transportation system stated, "We are going to hire additional people plus bring some more in from Palmdale (Calif.). I would say we need 200 to 300 more and it's going to take a little more time to get those people and then get them to do this work."

Yardley said some of the new tile installers "will probably be local (KSC) hires, but one of the problems we have is that it's a temporary kind of thing. Once they (the tiles) are on, then you really don't need all the people."

Of the 300 assigned to tile installation some 20 were transferred from Palmdale where Columbia was built.

McDonnell Douglas Technical Services Co. Inc. of the KSC was awarded by NASA a $5.2 million contract for interim cargo integration operations. The contract gives McDonnell Douglas responsibility over Cargo Integration Test Equipment which will verify a Space Shuttle payload's compatibility with the Shuttle Orbiter prior to installation.

April also marked the month in which the four Space Shuttle orbiters received their names. Orbiter 102, to be launched in late 1979 or early 1980, is named Columbia. Orbiter 103 is Discovery after ships that explored Canada's Hudson Bay from 1610 to 1611 and one of two ships that discovered the Hawaiian Islands in the 1770's. Orbiter 104 is Atlantis after a two-masted ketch that served as the first American-operated vessel designed especially for ocean research between 1930 and 1966. Orbit 099 is Challenger after a ship that from 1872 to 1876 gathered scientific data about the Atlantic and Pacific Oceans. Challenger was also the name of the Apollo 17 Lunar Module. The first Orbiter, 101, was named Enterprise in 1976 after the flagship of the popular television series 'Star Trek.'

SPACEMEN OBSERVE AURORA

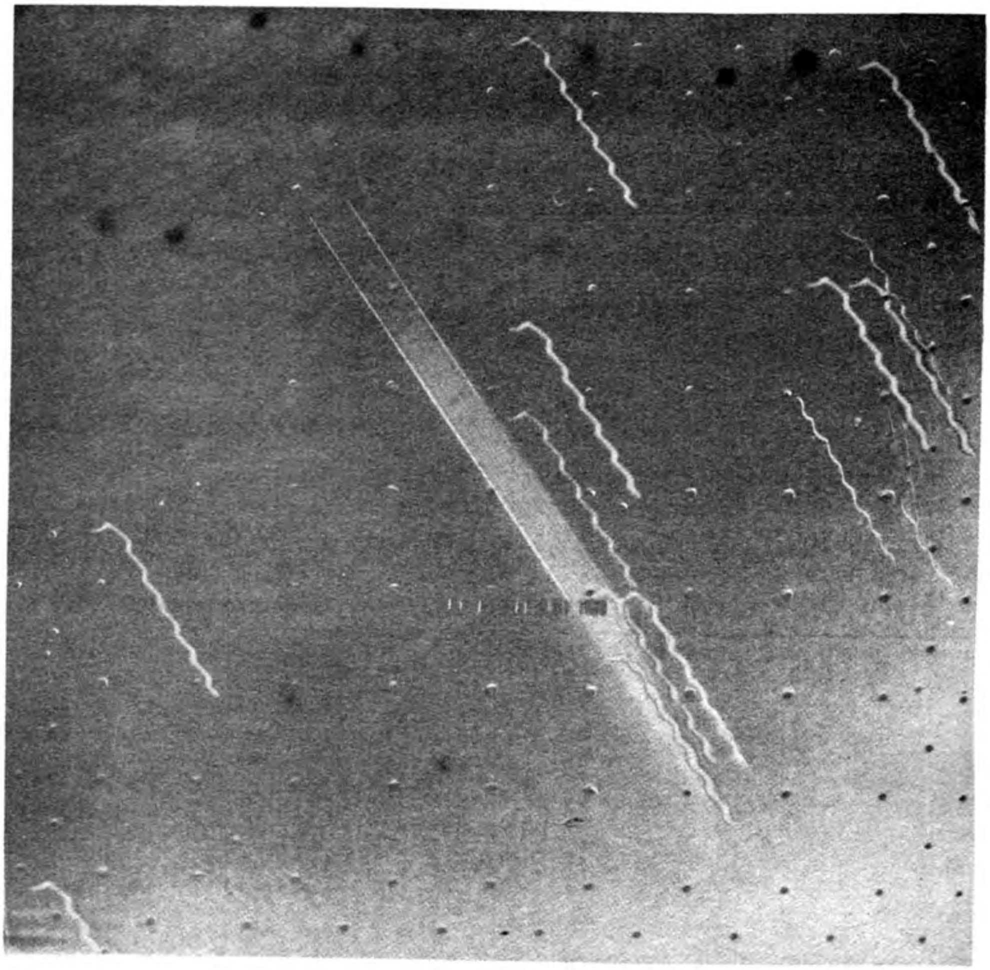
The terrestrial phenomenon of the Aurora occurs in the upper atmosphere on the border between the chemosphere and the ionosphere. Auroral emissions take place when there is a relatively greater loss of energy of magnetospheric particles to the atmosphere.

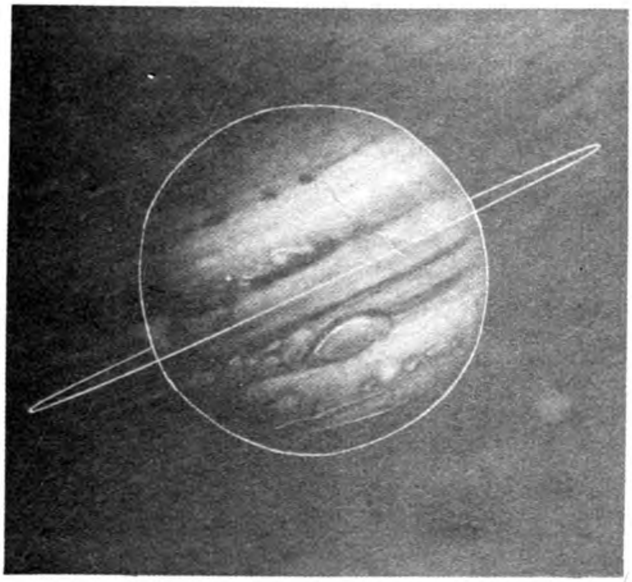
The magnetosphere, that enormous cavity formed by the terrestrial magnetic field, has an outward reaching configuration at the Earth's polar caps owing to the upward drift of the so-called polar winds.

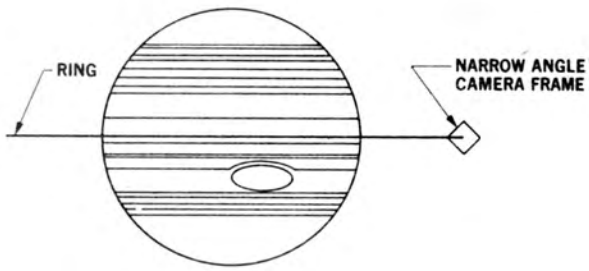
Auroral displays are the result of an energy deposition in the ionosphere, which occur periodically in sequence of events known as substorms. These magnificent displays were studied by spacemen Yuriy Romanenko and Georgiy Grechko who photographed them and made sketches with coloured pencils, writes Julian Popescu. They observed the great grade four auroral display over North America on 15 February 1978. Simultaneously Russian ground stations registered a magnetospheric substorm which reached the index of magnetic activity of over eight units. The lights according to Grechko were green near the Earth and red higher up. The two spacemen spent ten minutes passing through the shafts of light.

Spacemen Vladimir Kovalenok and Aleksandr Ivanchenkov witnessed auroral displays in the middle latitudes. A magnetospheric substorm occurred on 25 September 1978 and the two spacemen beheld a polar Aurora of great beauty. Nightly beams coloured green, pink, red and crimson stretched upwards to a height of 1,000km, reaching the upper layers of the mesosphere.

RING AROUND JUPITER. First evidence that Jupiter is a ringed planet is seen in this photograph taken by Voyager 1 on 4 March 1979. The multiple exposure of the extremely thin faint ring appears as a broad light band crossing the centre of the picture (top left to lower right). The edge of the ring is 1,212,000 km from the spacecraft and 57,000 km from the visible cloud deck of Jupiter. The background stars look like broken hair pins because of spacecraft motion during the 11 minute 12 second exposure. The wavy motion of the star trails is due to the ultra-slow neutral oscillation of the spacecraft (with a period of 78 seconds). The ring thickness is estimated to be 30 km or less.







SPACE AFFAIRS

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- Economics

SPACE RECOMMENDATIONS TO EUROPEAN PARLIAMENT

Welcome space moves have recently been made within the orbit of the European Parliament. In a motion for a Resolution submitted by the Committee on Energy and Research, the European Parliament was urged to support a more vigorous space policy much in line with our Society's own recommendations when advocating the creation of the European Space Agency some years ago.

The Motion before the European Parliament:

1. Stresses the importance of the benefits which the Community could derive in the short term from space activities, in particular in the following sectors:

   - *Telecommunications* (telephone and telegraph with fixed or mobile stations, information networks, television broadcasts, education);

   - *Earth observation* (meteorology and climatology, study of the Earth's resources with particular reference to agriculture, prospecting for mineral and oil deposits, land use, fishery resources, environmental quality control);

   - *Scientific research* (observation of the Universe, space physics, planetary exploration);

   and the industrial benefits of the technological results of space programmes;

2. Stresses the growing economic and political importance of space, and the long-term benefits to the Community of new space applications under study, particularly in the following sectors:

   - *Materials science* (manufacture of new substances or improvement of known substances in metallurgy, electronics and optics) and

   - *Biology and medical research;*

3. Believes that Europe cannot depend on outside sources to meet its own needs but that on the contrary the Community must, as far as possible, within the framework of broad international cooperation, play a significant role in the main sectors of space activity and make the necessary resources available to this end;

4. Believes that the Community possesses the necessary intellectual, technological and financial means to play an important role in space and that the programmes of the European Space Agency (ESA) represent one of the sectors in which European cooperation has proved most effective;

5. Believes that the Community can expect to play a decisive role in space only if it draws up a space policy setting out long-term objectives, providing the necessary funds and ensuring the active participation of all its member countries within a general European policy embracing the scientific, technological, industrial and economic sectors;

6. Believes that the time has come to examine space activities in the light of the development of an overall Community policy for science and technology;

7. Recommends that the activities of the ESA be progressively coordinated with Community efforts and that the Commission take the necessary steps to this end;

8. Recommends that the European Space Agency draw up a detailed European programme for the next ten years covering all the essential needs of its Member States with provision for implementing it as efficiently as possible;

9. Instructs its President to forward this resolution and the report of its committee to the Council and Commission of the European Communities.

In welcoming this new initiative, which is being actively promoted by the European Conservative Group, we particularly endorse the call for the definition of a new 10 year programme by the European Space Agency. Europe is now poised on the most exciting and potentially rewarding future in space technology thanks to the dedicated efforts of "the few" and it is vital that launch vehicle performance keeps pace with opportunities for new-generation satellites now appearing on the technical horizon.

The opportunities range from direct-broadcasting commercial satellites in Clarke (geo-stationary) orbit to scientific satellites and space probes.

We firmly believe that the new 10 year programme should take full account of new developments in rocket technology, building upon the excellent facilities which now exist for the Ariane launcher.

ESA would do well to examine opportunities for up-rating the Ariane launcher for future applications.

In this context we should not neglect new rocket propulsion systems using the ion-drive principle on which so much preliminary work has already been carried out – so far with little support – in Britain and on the continent.

AEROSPACE AND ENERGY

Ways to help save, supplement and replace some of Britain's energy resources were explained to Members of Parliament in the most effective way possible earlier this year by taking an exhibition into the Upper Waiting Room at the House of Commons. Called "Aerospace and the Energy Challenge," the exhibition was staged by British Aerospace, Rolls-Royce, the National Coal Board, the Electrical Research Organisation and British Rail.

The organisers stressed the need for:

- *the declaration of an overall U.K. energy policy for aerospace and the air transport industry.*

- *the formulation of an energy oriented research and development strategy for aerospace.*

- *funding support for U.K. industry on demonstrator programmes.*

- *demonstrations of the feasibility of more efficient processes to obtain synthetic liquid from coal.*

- *embarkation on industry-based studies towards solar power satellite systems.*

SPACE POWER. Dr. John Cunningham (right), the former Parliamentary Under Secretary of State for Energy, photographed with Mr. Douglas Fraser, Marketing Manager, British Aerospace Dynamics Group – Bristol. Dr. Cunningham visited the Group's solar power satellites display at the Aerospace & Energy Challenge Exhibition held in the Upper Waiting Hall of the House of Commons.

British Aerospace

- *accelerating the application of advanced technology in the rational use of energy in such areas as wind power and surface transport.*

On Solar Power Satellites, it was pointed out that British Aerospace Dynamics Group has the experience and capabilities necessary to play a leading European development role. The Group has been increasingly involved in space power systems for over a decade and is currently working on the two most powerful solar arrays in Europe.

Solar power satellites, stationed in geo-stationary orbit could receive solar energy *via* large arrays of photoelectric cells, convert it on board into microwave radio energy and beam it towards large receiving antennae on the Earth's surface. There the microwave energy would be converted to usable electric power and fed into the supply grid.

Many advanced technologies would be involved in producing these satellites including the possibility of fabrication in space using automated plant and large re-usable launching systems of the Space Shuttle type to carry the components into space. Highly accurate attitude control systems would be required to steer the very large 100 km^2 arrays continuously in the Sun's direction and to aim the microwave beam at the 18 km diameter receiving stations on Earth.

These satellites – the statement continued – are expected to provide electricity at competitive prices by the turn of the century when offshore supplies of oil and gas are approaching exhaustion. The investment required for their development is comparable to other major sources while the new technologies involved would advance British industrial capability in many areas and provide export opportunities on a major scale.

ANTI-SATELLITE TALKS

A frank and businesslike discussion took place at the recent talks in Berne on anti-satellite systems, according to the *Tass* news agency. The Soviet delegation at the talks, which lasted from 23 January to 16 February, was led by Ambassador O. Khlyostov, member of the collegium of the USSR Foreign Office Ministry, and the U.S. delegation by Ambassador Robert Buchheim of the U.S. Arms Control and Disarmament Agency.

BRITAIN'S 2½ PER CENT

Six Ariane launchers have now been sold for placing six geo-stationary satellites into orbit—and this before the first launch of a test vehicle. The economic and political importance of the Ariane project to Europe are considerable. Present estimates suggest that some 200 geo-stationary satellites may be due for launching between 1980 and 1990 and yet Britain makes only a 2½ per cent contribution and only four British companies are involved.

Three of these—Ferranti, British Aerospace and Marconi—are household names; the fourth, Avica, is a small but highly specialised engineering company of only 150 employees, based at Hemel Hempstead in Hertfordshire.

Avica is an example of the profit that can be made of unique skills in a branch of industry that has been badly neglected by successive governments. Avica's contribution to Ariana consists of the design, development and manufacture of bellows-sealed flexible joints in the fuel lines on all three stages of the launcher.

These joints allow axial and annular movement within the fuel lines to take place without high loads being induced in either the lines or the launcher structure to which they are attached. Also being supplied are stainless steel metallic hose lines and aluminium vee clamps for use in the control systems on the third stage.

Orders placed with Avica for the first five sets of production components will bring total orders received for this export work to well over one million pounds.

The other British companies involved in Ariane have the following responsibilities:- Ferranti: inertial platform; British Aerospace Dynamics Group: autopilot electronics, pogo-valves, release gear and certain carbon fibre struts for the engines; Marconi Space and Defence Systems: software for the central digital computer.

It is regretted that Britain has neglected to take a more active part in the development programme. Nine member states make financial contributions to the European Space Agency: Belgium, Denmark, France, West Germany, Italy, The Netherlands, Spain, Sweden and Switzerland. The UK participates under a bi-lateral agreement with France.

Prime contractor for the Ariane programme is the Centre National d'Etudes Spatiale (CNES) to which more than 50 European companies contribute. The first pre-operational launch is scheduled next month from Kourou in French Guiana.

AEROSPACE IN GOVERNMENT

Cabinet and Ministerial appointments in Britain's new Conservative Government headed by Mrs Margaret Thatcher —with an overall majority of 43 after the General Election on 3 May—include the following with responsibilities of particular concern to the aerospace industry.

Cabinet: Secretary of State for Industry, Sir Keith Joseph; Secretary of State for Defence, Mr Francis Pym, and Secretary of State for Trade, Mr John Nott.

Departmental Ministers: Minister of State for Trade, Mr Cecil Parkinson; Under-Secretaries, Mr Norman Tebbitt and Mr Reginald Eyre. Ministers of State for Industry, Mr Adam Butler and Viscount Trenchard, Under-Secretaries, Mr Barney Hayhoe, Mr Keith Speed and Mr Geoffrey Pattie.

In Sir Keith Joseph's Department Mr Adam Butler is responsible for Aerospace and Shipbuilding and Ship repairing, the Post Office, Steel, Cable and Wireless, and Research and Development will also be his concern. His Parliamentary Under-Secretary of State is Mr Michael Marshall.

SATELLITE DIGEST - 129

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed summary of the information presented can be found in the January, 1979 issue, p. 41.

Continued from the July issue]

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Cosmos 1090 1979-27A 11313	1979 Mar 31.45 13 days (R) 1979 Apr 13	Sphere + cylinder cone 5500?	5 long? 2.4 dia?	201	329	72.85	89.85	Plesetsk A-2 USSR/USSR
Cosmos 1091 1979-28A 11320	1979 Apr 7.27 1200 years	Cylinder 700?	1.3 long? 1.9 dia?	967	1011	82.93	104.95	Plesetsk C-1 USSR/USSR (1)
Soyuz 33 1979-29A 11324	1979 Apr 10.732 1.959 days (R) 1979 Apr 12.691	Sphere + cone-cylinder + antennae 6600?	7.5 long 2.2 dia	194 256 289	261 315 354	51.61 51.63 51.63	88.98 90.17 90.90	Tyuratam A-2 USSR/USSR (2)
Cosmos 1092 1979-30A 11326	1979 Apr 11.91 1200 years	Cylinder 700?	1.3 long? 1.9 dia?	966	1008	82.95	104.90	Plesetsk C-1 USSR/USSR (3)
Molniya-1 (43) 1979-31A 11328	1979 Apr 12.01 12 years?	Cylinder-cone + 6 panels + 2 antennae 1000?	3.4 long 1.6 dia	622 630	40595 39737	62.91 62.92	735.31 718.01	Plesetsk A-2-e USSR/USSR (4)
Cosmos 1093 1979-32A 11331	1979 Apr 14.23 60 years?	Cylinder + panels? 2500?	5 long? 1.5 dia?	620	633	81.25	97.29	Plesetsk A-1 USSR/USSR
Cosmos 1094 1979-33A 11333	1979 Apr 18.50	Cylinder?	6 long? 2 dia?	427	445	65.02	93.31	Tyuratam F-1-m USSR/USSR (5)
Cosmos 1095 1979-34A 11335	1979 Apr 20.48 14 days (R) 1979 May 4	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	197 355	379 416	72.85 72.85	90.31 92.31	Plesetsk A-2 USSR/USSR (6)
Raduga 5 1979-35A 11343	1979 Apr 25.16 indefinite	Cylinder + 2 panels + 2 antennae	5 long? 2 dia?	35789	35789	0.41	1436.2	Tyuratam D-1-E USSR/USSR (7)
Cosmos 1096 1979-36A 11346	1979 Apr 25.42	Cylinder?	6 long? 2 dia?	430	444	65.05	93.33	Tyuratam F-1-m USSR/USSR (8)
Cosmos 1097 1979-37A 11348	1979 Apr 27.72 13 days (R) 1979 Apr 10	Sphere + cylinder-cone 5500?	5 long? 2.4 dia	174	336	62.79	89.60	Plesetsk A-2 USSR/USSR

Supplementary notes:

(1) Cosmos 1091 may be a navigation satellite.

(2) Unsuccessful attempt to place an international crew aboard Salyut 6 to join cosmonauts Lyakhov and Ryumin. The Soyuz 33 commander was Nikolai Rukavishnikov and his flight engineer was a Bulgarian Georgi Ivanov. Launched at 1734 UT on Apr 10, a problem arose in the approach manoeuvring engine at 1854 UT on Apr 11 and the planned link was abandoned. At the time, Salyut was in a 338 x 355 km, 91.41 min orbit. Soyuz 33 landed at 1635 UT on Apr 12. Orbital data are at 1979 Apr 10. 9, 11. 7 and 11. 9.

(3) Cosmos 1092 may be a navigation satellite.

(4) Domestic communications satellite replacing Molniya-1 (32), 1976-06A. Orbital data are at 1979 Apr 12.6 and Apr 20.2.

(5) Possibly an ocean reconnaissance satellite using sideways looking radar, similar to Cosmos 954 – the nuclear powered satellite which landed on Canada. The orbit of Cosmos 1094 is about 200 km higher than that of Cosmos 954 and is more reminiscent of that of Cosmos 937, 1977-77A. Cosmos 1094 carries a microthruster for small orbit adjustments.

(6) Orbital data are at 1979 Apr 20.5 and Apr 21.5.

(7) Communications satellite in geostationary orbit located at the Statsionar 1 position (over the Indian Ocean).

(8) Similar satellite to Cosmos 1094 (see note 5). Cosmos 1096 was launched into the same orbital plane but approximately 23 minutes ahead of Cosmos 1094.

Amendments and decays:

1971-105A, Cosmos 461 decayed 1979 Feb 21, lifetime 2638 days.
1973-18A, Molniya-2 decayed 1979 Jan 6, lifetime 2102 days.
1975-39B, Castor decayed 1979 Feb 18, lifetime 1373 days.
1979-22A, Progress 5 orbital data are at 1979 Mar 12.4, Mar 13.4 and Mar 14.5.

EARTH RESOURCES IMAGERY

The UK National Point of Contact for ESA/Earthnet has been in operation at the Space Department, Royal Aircraft Establishment, since 1 December 1978 and all persons on the distribution list for E.R.I. Information Notes should by now have received their copy of the NPOC Users Guide.

All enquiries should be addressed to Miss. E. J. Lindsay, RTS 2C, Department of Industry, Room 604, Abell House, John Islip Street, London, SW1P 4LN, enclosing s.a.e.

Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

CONTENTS

SPACEFLIGHT

A Publication of The British Interplanetary Society

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MILESTONES

May

10 NASA signs agreement with Thailand for the establishment of a Landsat ground station in Bangkok.

15 Progress 6 docks with Salyut 6-Soyuz 32 complex using second (aft) airlock.

16 NASA reports that multispectral scanner of Landsat 3 "is now producing some randomly defective images". Since the 950 kg. (2,100 kg.) satellite was launched on 15 March 1978, the equipment has scanned and obtained data on over 91,000 scenes, each representing an area 185 x 185 km. (115 x 115 miles) of the Earth's surface. *(Landsat 2, having taken over 325,000 images, is still working satisfactorily. Ed.).*

23 Soviets launch Cosmos 1100/1101 by single carrier rocket from Tyuratam into orbit of 199 x 230 km. x 51.6 deg. They were both returned to Earth, possibly recovered, in just over 0.2 day. (RAE Table of Artificial Earth Satellites, issued 4 June, gives individual masses as 12,000 kg. (?) which could imply use of an uprated Proton launch vehicle). Experiments–thought to be related to Soviet manned space programme–are similar to those of Cosmos 881/882 and 997/998 in which both 'sputniks' were returned same day.

23 First firing of flight-rated Ariane first stage is made at Vernon facility of Societe Europeene de Propulsion. Burn lasted full duration of 139 sec.

25 *Soviet Weekly* reports that Vietnamese cosmonauts are being trained at the Gagarin Centre under the Interkosmos programme.

29 China is reported by *Aviation Week & Space Technology* to be developing a spacecraft to send men into space. Dogs and mice have already been launched on sub-orbital trajectories.

30 US Department of Defense confirms that work on laser beam weapon system is now "well beyond the breakthrough stage". Because laser beams are more effective in thin air or vacuum, they could be placed on mountain tops or in space vehicles for defence against missiles and satellites.

[Continued overleaf

COVER

DRESS REHEARSAL. During the summer the Space Shuttle 'Enterprise' was rolled out from the Vehicle Assembly Building at the Kennedy Space Center and taken to Launch Complex 39A to clear the way for the launch of its sister ship 'Columbia' next year. *Top,* this helicopter shot depicts the scene after 'Enterprise' on the Mobile Launch Platform had arrived on the pad. *Right,* 'Enterprise' is moved from the VAB on the crawler-transporter. *Below,* approaching LC-39A and the rotatable service platform (more pictures on pages 389-390).

National Aeronautics and Space Administration

BIS ANNIVERSARY SUPPER

at 6.30 pm. for 7.30 pm. on Friday, 19 October 1979, in the Surrey Hall, Binfield Road, Stockwell, London SW4. (200 yards to the left of the exit of Stockwell Underground Station).

An informal get-together for members, their families and friends to mark the 46th anniversary of the founding of the BIS on 13 October 1933. Bar available. Admission by ticket. Price £1.50.

(Ticket admits bearer to view Society's Conference Room and Library from 5.30 to 6.30 pm. at 27/29 South Lambeth Road, London SW8 1SZ on 19 October 1979).

Apply for tickets to the Executive Secretary of the Society.

June

2 Reported that Soviets have postponed joint spaceflight with Hungarian cosmonaut because Salyut 6 ferry has exceeded its operational life. Soyuz 32 has been docked to the space station for 98 days, eight days longer than recommended. Soyuz 33, flown by a Russian and a Bulgarian, had to abort last April after failing to dock. They were to have returned in Soyuz 32 leaving their ferry for use by long-duration cosmonauts.

3 Russia expects to launch heavier, multi-purpose space station, according to Roald Sagdeyev, director of Institute of Space Research. Such stations will be crewed by cosmonauts at first but gradually their main operations will be automated, with cosmonauts visiting them only periodically.

3 NASA launches scientific satellite UK-6 (Ariel 6) by four-stage Scout at 23.26 GMT from Wallops Island, Virginia, into 625 km. circular orbit (see *Spaceflight*, July 1979, p.308). Satellite is controlled from the Winkfield ground station in conjunction with the Operations Control Centre at SRC, Appleton Laboratories, Slough. Research objectives include study of nuclei of cosmic rays and variable energy x-ray sources related to neutron stars, supernovae, black holes, radio galaxies and quasars.

6 ESA reports that the Ariane propellant mockup campaign at Kourou, French Guiana, has been completed. Four fills of the third stage with LO_2/LH_2 and a fill of the first and second stages with storable propellants preceeded a rehearsal (16-17 May) for the launch countdown, identical with that for real launches. This concluded with an automatic sequence which was halted at minus 6 seconds, just before engine light up. The jettisoning of various electrical, pneumatic and filling connections was also tried out. The first flight vehicle, Ariane LO1, is expected to be shipped to Kourou in early September with the expectation of launching in November.

6 Soviets launch unmanned Soyuz 34 from Tyuratam cosmodrome at 9.13 pm. (Moscow time) into orbit of 198 x 270 km. x 51.6 deg; period 88.9 min.

6 Cosmonauts Vladimir Lyakhov and Valery Ryumin measure the flux of gamma-radiation and charged particles in near-Earth space by Yelena gamma-telescope; they also carried out visual observation and photography of Earth.

7 Soviets launch India's second artificial satellite, Bhaskara, into an orbit of 512 x 557 km. x 50.7 deg; period 95.15 min. Object is to study Earth's natural resources through TV and microwave radiometers of Indian design and manufacture. (Launch of Bhaskara had been expected in February, as indicated in our exclusive article, *Spaceflight*, July 1979, pp. 300-301. Owing to postal delays in the London area, corrected proofs explaining the delay did not reach our printers before the issue went to press).

8 Soviets offer to fly an Indian scientist into space as part of the Intercosmos programme.

8 Soyuz 34 docks with Salyut under the control of cosmonauts aboard the station. Craft brings "material required for scientific experiments, additional equipment and food".

8 Dr. Robert Huguenin, University of Massachussets, tells meeting of planetary geologists in Providence, Rhode Island, that two "wet regions"–possibly underground lakes– have been discovered on Mars, increasing the chances that microbic life exists on the planet or beneath its surface. Discovery was made by an instrument aboard a Viking orbiter and corroborated by an Earth-based telescope using a spectrograph. The two sites, *Solis Lacus* and *Noachis-Hellespontus*, are 400 miles (644 km.) and 720 miles (1,159 km.) across respectively.

8 Progress 6 separates from Salyut 6 at 11.00 hr. (Moscow time) to allow unmanned craft, Soyuz 34, to dock with the space station. Docking was carried out "flawlessly" at 23.02 hr. (Moscow time) under the control of Vladimir Lyakhov and Valery Ryumin who had been aboard the station more than 100 days.

9 French national space agency CNES outlines proposals for up-rating the Ariane launcher. Methods include increasing chamber pressure of current Viking 4 and 5 engines; increasing propellant volume of third stage, adding solid-propellant strap-on boosters. Studies are being made of the possibility of recovering the first stage; and an up-rated launcher is proposed capable of carrying a mini-shuttle, 'Hermes', to give Europe experience in manned space flight in low Earth orbit. The 9,500 kg. (20,940 lb.) mini-shuttle could be placed into a 200 km (124 miles) orbit inclined at 30 deg. to the equator from Kourou, French Guiana.

10 *Tass* reports that Progress 6 has burned up in the atmosphere after completing its flight.

12 First clustered full-thrust firing of three Space Shuttle Main Engines is made at National Space Technology Laboratories, Mississippi. Planned run of 520 sec. is automatically terminated at 55 sec. by spurious signal indicating excessive vibration. Engines were mounted in simulated Orbiter structure and drew LO_2/LH_2 from External Tank. Fault was in the ground test equipment.

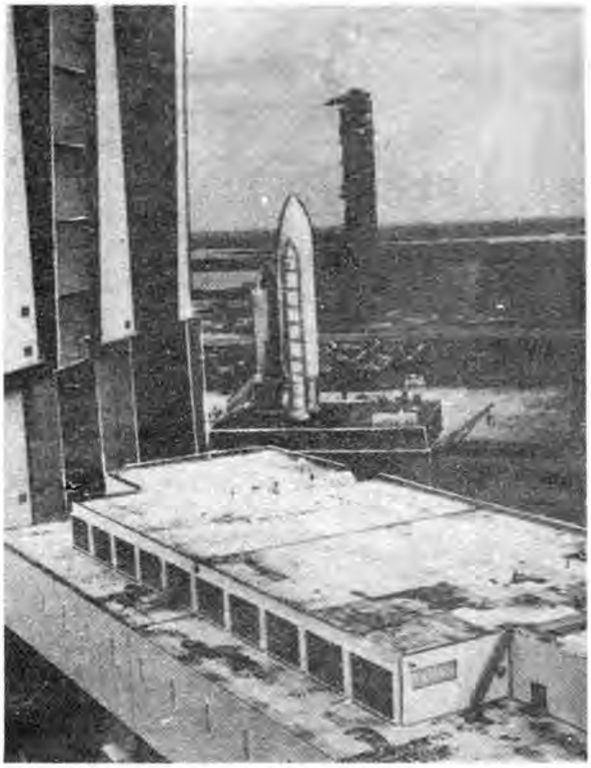
13 *Tass* reports that Soyuz 32, the ferry in which Lyakhov and Ryumin joined Salyut 6 in February, has been returned to Earth unmanned. The re-entry module containing results of experiments landed in the pre-set region in Kazakhstan.

14 Cosmonauts Lyakhov and Ryumin enter Soyuz 34, separate from the aft docking port of Salyut 6 and pull 100 metres (328 ft.) clear. Salyut 6 is turned through 180 degrees to permit them to re-dock on the forward airlock.

19 *Soviet News* reports that USSR Academy of Sciences and Indian Space Research Organisation have signed an agreement covering the building and launch of a third Indian satellite between 1980-81. Object of Soviet-Indian programme is to study Earth's natural resources and conduct astrophysical and meteorological observations. *(Soviets also have offered to fly an Indian scientist into space under Intercosmos programme. Ed.).*

22 Soviets reveal that the first 2.5 million acres (nearly 4,000 miles^2) of forest in the region to be served by

[continued on page 401



DRESS REHEARSAL for the first manned space flight began at Cape Canaveral on 1 May when the 'stand-in' vehicle 'Enterprise' was rolled out from the Vehicle Assembly Building on the Crawler-transporter.

National Aeronautics and Space Administration

technologies and services. We can see today the eventual possibilities of true interactive global data systems routinely serving the needs of all societies for accurate information – on food and fibre crops, on weather and climate, on sea state and land use, on demography, energy, pollution, and natural resources. We see space sensor data being combined with data from other, more conventional sources, and then being electronically manipulated, analysed, and available for display anywhere in the world. We see the wise management of our fragile planetary biosystem on a global basis becoming a real possibility – and largely because the viewpoint from space, and the communications through space, expand the human horizon. We propose to have man think – and plan and act – on a worldwide scale: the narrower local boundaries of city and state and even continents are not respected by the major phenomena that make the world inhabitable.

In a nutshell, space is becoming useful. We are therefore, in my opinion, enetering upon a new area of accountability as to what to do in space, who should do it, why it is best done there, and how well it must be done to be worth undertaking in the first place. In other words, our standards of selection – and of success – are maturing along with our technical capabilities.

When something is useful – rather than only novel, or exciting, or arcane – individual interests become paramount. And it is the fair and equitable recognition of those often divergent interests that is a proper subject of public policy. I am sure some of you will agree with Plato, when he had Socrates tease his pupil Glaucon about feeling he had to justify the study of astronomy on the grounds of being practical for farmers, sailors, and soldiers. I am sure others of you agree with the perhaps apochryphal quotation of the future utility of electricity: "Someday you'll tax it." Still others may prefer Voltaire's view that we should cultivate our own gardens. It is nonetheless a truism that the discovery of utility seems to bring in its wake concepts of rights, of property, of control and allocation and protection – in short all the notions of economic man. Some of these, in the context of space, can raise quite important questions, domestically or internationally.

Questions of Space Law

Take, for example, the question of the "ownership" of space. As you know, there has yet been no legally defined and accepted line drawn between air and space – and therefore no obsolute demarcation of vertical sovereignty. Given today's technologies, there can be no useful analogy with the old three-mile limit originally established by the range of coast defence batteries. There are some who lay sovereign claim to that particularly important band of space 22,300 miles above the equator – the only place we can park satellites in geostationary orbits. While the present preponderance of international opinion forswears such ephemeral appropriation, there is a growing feeling of crowdedness in that large but finite band, especially at the preferred locations for terrestrial communication services. In Daniel Boone's day, a pioneer moved on when he first could see the smoke of his nearest neighbour's chimney; satellites are running out of that luxury, both in physical space and in radio frequency spectrum. What can we look forward to when the heretofore exponential expansion of technical solutions reaches its natural limits – but the appetite of society for moving information about electronically has not been satisfied.

Take the somewhat related question of direct broadcast satellites. There are some who feel very strongly about the propriety of unedited programming reaching the home receiver – so strongly, in fact, that such an activity has been proclaimed in advance as a possible cause of hostilities, or at least of direct retribution. This view conflicts rather directly with an ethos wedded to a free exchange of ideas among all peoples. Yet some form of restraint is imposed almost universally on various communications media within sovereign states, whether it be that of censorship, good taste, or common sense. Are direct broadcast satellites – a relatively easily implemented concept – in reality such socially dangerous tools as to become a justification for extending the already crowded terrestrial battlefields into space?

This leads of course, to the larger issue: can space retain an Antarctic innocence in light of its growing utility to the power of individual nations? Or will the flag inevitably follow trade, and then the fleet the flag? Another tier of weapons is hardly what the global society needs in order to assure its civilised survival. Yet, on the smaller scale of national activities, threat will be met by counter-threat and armed force by armed resistance unless a new level of restraint can be institutionalised.

And then there are those activities in space which, contrary to the intentions of their managers can be perceived as threats of another kind. Beacons and transmitters interfere with each other and with their terrestrial counter-parts. Space debris is building up, and it seems only a matter of time before random crossing orbits will result in an extra-terrestrial collision. Particulates from rocket exhausts and material release experiments may build up to deleterious levels. Beamed solar power from space, a possible future alternative to fossil fuels, raises some new questions about microwave effects on the biosphere. Does modern civilisation inevitably mean pollution of each ecological niche into which it expands?

ENTERPRISE–on the Mobile Launch Platform–begins its 3½ mile journey to Launch Complex 39A on the giant crawler. This marked the first time that the complete Space Shuttle configuration was assembled and moved to the pad. *NASA*

Take also the question of the shareholder's interest. For a governmental programme, as are most but not all space activities today, the shareholder is the taxpayer. When a space activity, like the United States Landsat programme, begins to show real economic potential, then the question of return on investment must be faced. In an experimental phase, the issue is less pressing, since the process of scientific inquiry and early learning is deemed worth the R&D cost; in this phase, an open-handed sharing of new data with virtually any interested party or nation has been the norm. But, as a capability approaches operational status, the shareholder has the right to question a policy of virtually free distribution of a product that has cash value. This becomes even more pointed if we look forward to a point when private industry may own space instruments gathering global information of particular value to various economic and social and political sectors. The profit motive will have to operate, and the price of space-acquired data – as well as the unique information derived therefrom – will have to reflect its real cost. It must be noted that the same data or information set can have high values for quite different applications: for example, global food and fibre production forecasts, based on space data, *if* timely and accurate, can allow the mounting of useful relief programmes, can guide national agricultural policies, can benefit exporters, and can effect the specialised commodities markets. Clearly, these can become competitive rather than complementary ends. In our system, competition establishes value and, to some extent, price. Can any of us afford to see global economic information being marketed under traditional rules? Can Earth resources imagery from space be copyrighted? Can a data stream? Does the owner of a field have a property right in an image of that field, or in an analysis of its productivity? In the long run, the knotty questions of data rights will have to be resolved – they are, of course, being kept under constant assessment by many governments and institutions – if only to provide a stable environment for an organised flow of benefits in relation to costs, and for an allocation of responsibilities and liabilities among the interested parties.

These examples to my mind all have a strong flavour of public policy, None is easily resolved. None seems to have a pristine precedent or apt analogue in pre-space tradition. Each deals with rather vital human or institutional interests, ranging from nutrition to privacy. Each is potentially the subject of significant political disagreement, demarche, or determination. The United States has, within the structures of Presidential policy-making machinery and of international consensus, been grappling with these for some time; the practical technical imagination of men, however, seems always a step or two ahead of the latest practical policy formulation.

Let me stress that these are only examples – and even then, only a few – of the kinds of questions a successful and useful technological revolution brings to the surface. I hope I have provided some framework for discussion; I know I have provided no final answers. But before anyone feels that such answers are easily come by, I would paraphrase Lucius Armilius Paulus, Rome's commander against the Macedonians:

> *If anyone feels qualified to give advice respecting the conflict we are about to enter, let him not refuse his assistance to the state but come with me into Macedonia – and share the dangers.*

SCIENCE AND EXTRATERRESTRIAL COLONIES

By David G. Stephenson *

Introduction

The development of human societies in alien extraterrestrial conditions will demand fundamental changes in our current patterns of thought and social behaviour. Ross, in the July 1978 issue of this journal, suggested that there must be a fundamental improvement in the perspectives of mankind based on an objective view of human society if we are to develop a stable society in the Solar System and perhaps beyond. This article attempts to examine a weakness in an objective approach to the development of human societies based on high technologies as exemplified by possible extraterrestrial colonies.

Our Present Condition

The end of the 20th century can be likened to the era during which the Roman Empire slowly crumbled under the effects of internal and external social and economic pressures. We live in a time when long established human structures are called upon to adapt to a dramatically changing and therefore uncertain view of the Universe. As Toynbee describes in *Mankind and Mother Earth* the old Roman pantheon was found to be inadequate for the peoples of the 3rd century A.D., a time of political warlords, economic chaos, and barbarian incursions on the Empire. The need for a closer relationship with the deity than expressed by the old elemental gods finally culminated in the establishment of Christianity, which portrayed Man as a being specially created by a forgiving God, and having a unique and dominant position over Nature. This new view of Man in the Universe a millenium later played a fundamental role in the development of the techniques of modern science. These in turn have revealed Man to be a small vulnerable creature that is part of a fragile biosphere lost in a Universe grown aweful by the vastnesses of time and space.

Just as the Roman Empire fostered the growth of Christianity with its novel world view, so must our age develop a new model of Man in his relationship with Nature, a model that is adequate to the challenges of the future. The foremost of these challenges is the construction of human societies beyond the Earth in planetary and possibly stellar space. To succeed we will have to learn to wield forces both physical and social that a generation ago would have seemed awesome. In particular the social changes inherent in such a venture expose the weakness in our current dependence on a scientific approach that reflects an image of Man as a being apart from the forces that are Nature, including those that shape his own societies.

The Scientific Method

Fundamentally, the methods of modern science are a means of communicating information between human beings. Certain experiences are recorded in an agreed style to be communicated to others who appreciate the model of the Universe being used to define the primary experience. By means of books or other records this reservoir of experiences is made available to humans separated in time and space. Like any language between human beings a common ground of experience is required before communication can take place, and that common ground is defined and expressed by the language itself. If the reader does not appreciate this fact, try the mental exercise of describing snow to an inhabitant of the Amazon Basin jungle, and the problems of establishing a set of common references is immediately apparent. The profound strengths and weaknesses of the modern scientific method are inherently intertwined in the model of the Universe that is the common ground of the communications that are science.

The primary postulate of modern science is the assumed existence of a common, detached, and unaffected observer of the Universe. Classically, the ideal observer is absolute and unresponsive to collected information that has itself been collected from a perfectly elastic Universe. Throughout scientific literature is the implication of this observer's objective view, and of course all scientific papers are presented in the passive voice with an abstract agent. The great step forward out of the classical theory of science was the realisation that on the atomic scale the Universe was fundamentally plastic. In certain circumstances the observer of the phenomena of nature will cause an unavoidable and permanent distortion expressed as the uncertainty principle. At the same time the theory of relativity demanded that, when considering information transfer close to the velocity of light, the single observer must be replaced by a infinity of independent observers, each of which retains the properties of the classical observer.

Of course no member of the human race could truly act as a scientific observer, in that his observations must unavoidably alter his mental status in ways other than the retention of information. When acting as scientists, human beings attempt to mimic an isolated, unaffected viewpoint by applying the principle of experimental reproducability. The construction that results is essentially a statistical concensus of the experiences of many individuals, and is justified by the consistency of the data obtained by the method. But consistency is only obtained when the individual transmits his experiences in a way that another can demonstrably experience; in other words intimate personal reactions must be ignored. This means that the scientific method is successful only in observing events that do not impinge on the intimate mental structure of a human being. Thus the scientific method has been most powerful in constructing a model of the physical phenomena of the world around us, and in tackling other problems where there were enough resources both human and physical to allow the responses of individual human beings to be ignored.

Where do we go from Here?

In my view the article published by Ross and mentioned in the introduction, reveals the fundamental conflicts in our modern thought patterns that must be resolved by the evolution of a more advanced 'Universe model' if mankind is to truly take his place amongst the stars.

The scientific method requires an objective, detached, observer, who therefore cannot be a fully functioning member of the human race. A human being does not exist in isolation, and I find many facets of current economic and political theories repugnant because of the attempt to dehumanise the individual, so that the scientific method with its detached observer can be applied to human society. When I meet another human individual my reactions are not objective, but very subjective, and therefore they cannot be "scientific". Ross, however, regarded the objective development of a society consisting of individuals as a prime concern. This is a contradiction in terms. If a person wishes to be scientific about his reactions to other human beings, he must construct a mental agent that observes the emotions and ignores them. To supervise the constructed mental agent a second observer is needed....and so on. The end result of trying to be scientific towards other human beings is a spiral dive into the ultimate black hole of Cartesian thought, solipsism.

The scientific method is a set of extremely powerful

* *The University of Saskatchewan, Saskatoon, Sask, Canada.*

mental tools, evolved to handle certain limited concepts, rather as a spanner is very capable of rapidly adjusting nuts and bolts. I think few of us would sacrifice our arms and hands to replace them with monkey wrenches for the better manipulation of nuts and bolts. Imagine trying to embrace someone while using monkey wrenches in place of hands! Yet, foolish though the example may seem, I think this is exactly analogous to the over-eager application of the scientific method to the problems of a human society consisting of individuals. A common complaint of modern social sciences is that they must reduce people to numbers. Indeed they must, for mathematics is the language of science and therefore numbers are an expression of the detachment needed by the scientific method. As spanners are very useful for their designed purpose, so is the scientific method, but we must be aware of the limitations imposed on our view of human society by the construction of a detached observer. Above all we must resist the temptation of the cave man within us to take the monkey wrench of science and use its sheer cold mass as a club against people that we do not identify with ourselves.

E.T. Societies

By their nature possible extraterrestrial societies of the next centuries may be the forcing ground of a new human perspective on the Universe. The occupants of these colonies will necessarily be some of the most technically able members of the human race, who will be living in a confined society in which interaction with other such human beings at an intimate level will be unavoidable. The colonists will have to be in control of aspects of their environment that previously were beyond the control of human beings. The limitations of attempting an objective analysis of the structure of such a society is exemplified by applying the objective view to one of the critical aspects of society such as 'birth control' which was mentioned by Ross.

Even on Earth human societies have assumed a bewildering variety of forms, and therefore the imagination should have almost free range to consider possible social forms of extraterrestrial colonies.

The difficulties associated with preserving a stable population density of human beings in a limited habitat can be resolved by a spectrum of methods, and to suggest birth control is to reveal a distinctly subjective, i.e. non-scientific, viewpoint. A completely detached intelligence would conclude that 'for a medically and hygienically able species, *homo sapiens* is grossly over-sexed', and would objectively prescribe eugenic engineering to reduce the human sex drive. Indeed, there may be many advantages to extraterrestrial colonies based on the forbidden city of Peking and staffed mainly by eunuchs. Such a colony would approach the ideal monastic state of the middle ages in Europe. At one time or another human societies have controlled their populations by large scale human sacrifice (Aztecs), canibalism for meat (Maoris), infanticide (Sparta, 18th century England), abortion (global human characteristic), as well as many types of contraception. Usually these techniques were reserved for use by one section of a population on another. As an objective view forbids identification with the controlled population these methods may be part of a scientific analysis of a (possible) extraterrestrial colony. If the reader is shocked by the suggestion of these systems of population control the reader has identified himself as one of the colonists, and is repelled by the thought of the programme being applied to himself. That identification is the step out of the realm of science, for now he is participating in the phenomena being discussed, and therefore he is unable to take the objective stance demanded by the scientific method.

Each colonist in the extraterrestrial settlements will be a participant that must accept an identification with and a high level of responsibility for every other member of the colony. Historically, expeditionary groups have depended on a structure that grew from the hunting groups of primitive man. This placed the responsibility of the group onto one man and reached its final form in the 'old man' who was master of the clipper ships. In an extraterrestrial colony, all the colonists will have to be highly able individuals while most of the routine drudgery of living will be carried out by machines and it is unlikely that the primitive hunting group social structure will be sufficient. Each colonist will have to participate in society as a complete human being, not merely as a specialist with a limited, but objectively viewed function. A new subtle form of human language will have to be developed to allow the intelligent, imaginative, and sophisticated colonist to play a full and complex role within what will be a unique human grouping. There will be no opportunity for any member of the colony to abstract himself from the colony's social structure for the formation of an objective view of a problem that concerns the colony.

Utopia?

The Universe model that has held the attention of western man since the growth of Christianity is eschatological with an expectation of a glorious conclusion to history within a human time scale. With the decline in belief in the concept of a Last Judgement and a New Jerusalem, this Universe model has been expressed by various forms of ideological or technological utopias as the end point of human development. Unfortunately, such utopias run counter to a basic human characteristic of satisfaction in action. Mankind is an intelligent species (therefore a curious species with a constant appetite for the new and different not a stagnant certainty, no matter how pleasant. An objectively developed social charter could at best result in such a stagnant Utopia, in that the dynamic participation of the individual members would have to be ignored for the scientific method to function. Only a passing non-human alien could be objective about a human social charter, since we are all members of the human race and unavoidably intimately concerned with its destiny.

The task facing ourselves as members of twentieth century human society is to recognise the limitations of our current mental tools, and to add the dimension of interaction to modern science, thereby enabling a fuller communication of the subtle, intimate inter-human forces that are the nature of human society. This is indeed a *magnum opus*, being a fusion of science with aspects of religion, philosophy and the arts. Only with such a vehicle for the experiences of mankind in a vast and infinitely complex Universe, can the human race elevate its members to being inhabitants of the Solar System and the bodies and spaces beyond, rather than being merely colonists from the surface of planet Earth.

DEMETER: ISLAND IN SPACE

By Dr. Frank D. Hess*

Introduction

Another contribution to the list of space habitat concepts should justify itself by a mention of features not previously described, or should at least offer refinements that represent a significant advance over present models. In the course of a literature search for a habitat model suitable for a work on space agriculture [1], the writer reviewed the models developed by von Braun, Bernal, O'Neill and others, and summarised in a NASA-Stanford workshop report [2], and concluded that this subject is generally not accorded the treatment its importance warrants, being secondary to residential, occupational and recreational arrangements. I therefore undertook a new approach, that of modelling a space agricultural facility with room for other operations such as space manufacture, and found that a habitat design developed logically and naturally from the requirements for growing food, recycling waste and regenerating a breathable atmosphere.

This article deals with the whole habitat concept, and is believed to represent an innovative approach to radiation shielding and hull structure. Borrowing the name of a Jovian satellite, I have termed this concept Demeter.

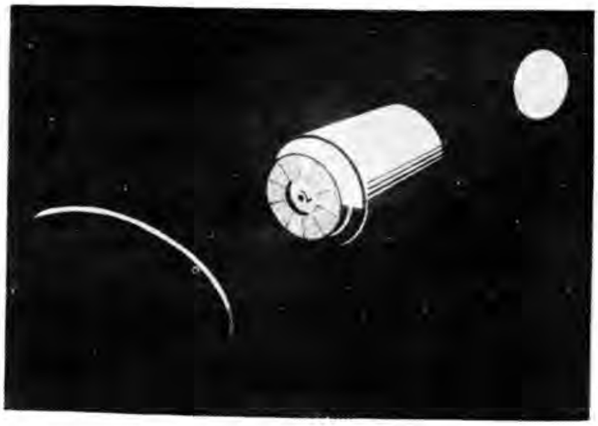


Fig. 1. Demeter.

Search for a New Model

The premises on which this model is based include:

- It describes a second-generation habitat with room for 10,000 settlers of all ages, sexes and conditions. This size allows for full diversity of agriculture, e.g., a varied animal husbandry, that could not be undertaken on a much smaller scale.
- Lunar-derived materials are presumed to be available for its construction, with minimal logistic support from Earth.
- Modular construction, replication and provisions for later enlargement are introduced as far as possible.

Predicated on these inputs, a plan was devised for a space habitat in which the shielding is made from lunar materials with minimal processing. The shield is structurally self-supporting and contributes to the support of the rest of the habitat, reducing the need for metal fabrication.

A blend of residential and agricultural areas helps relieve awareness of crowding, provides green surroundings and gardening opportunities, and introduces oxygen directly into living areas.

Zero-g and vacuum fabrication shops are inside the radiation shielding, making it unnecessary in this respect to place constraints on working hours.

Internal layout is flexible, avoiding monotony and replacing, to some extent, the Earth's pattern of the seasons with a changing variety of fruits, flowers, vegetables and cereal crops.

Against these desirable features must be placed some liabilities, the first being a requirement for a much greater radiation shielding mass than is proposed for most alternative designs. For equal population densities, however, the shielding mass is generally in favour of the Demeter configuration.

A second liability is the need to relax the NASA guideline [2] for the rate of habitat rotation, 1 rpm, to a figure of 1.25 rpm, in order to keep the diameter within reasonable bounds. This rate should not be troublesome except to a few individuals with inner-ear problems; however we recognise that the whole matter of tolerance to low spin rates must still be investigated.

A potential liability that remains to be evaluated is the possible loss of strength in the glass by devitrification (crystallisation). This is a problem common to all habitat designs with glass windows; these however can be replaced panel by panel. Will radiation damage accelerate the devitrification of the glass fibre, and can it be compensated by later additions of cable? These questions should be answerable by laboratory experiment.

The Configuration

A brief review of possible configurations for a space habitat is given in the NASA study [2]. This points out the fact that there are four general habitat shapes, all generated by rotating Cassini curves about one axis. The resulting shapes are the sphere, the cylinder, the torus and the dumbbell. Different groupings of these shapes are possible to improve strength and habitability; we may have the single torus (doughnut), the banded (stacked doughnuts), the beaded torus (fused dumbbells), the cylinder with spherical endcaps, and the multiple dumbell, which resembles stacked flyball-governors. To these we may add O'Neill's "crystal palace" configuration [3]; this may be described as a nested multiple-beaded torus, a shape which withstands pressurisation with minimal requirement for structural mass.

Demeter, the habitat discussed here (Figs. 1, 2, 3) is a thin toroid within a cylinder having oblate endcaps. The spindle-shaped body in the centre of the cylinder is a stationary free-floating workshop area. Free-floating mirrors located outside the cylinder at a distance of about three kilometres provide solar energy for lighting and photovoltaic power. The inner torus provides the living and agricultural areas. This area is only about 50 metres "high", i.e., the height of a 15 storey building. This limits the mass of atmosphere that must be provided, since the nitrogen or other inert dilutent must be supplied from the Earth. There is little prospect of finding adequate sources of nitrogen either on the Moon or the asteroids, though Jupiter or the Jovian moons may serve some day as a source of nitrogen in the form of ammonia. The torus, however, is expandable; when more nitrogen is available the "roof" may be raised to give more living space.

To admit light but exclude harmful solar and cosmic radiation, an opening fitted with a long hublike tube is

* *The Aerospace Corporation, Los Angeles, California, USA.*

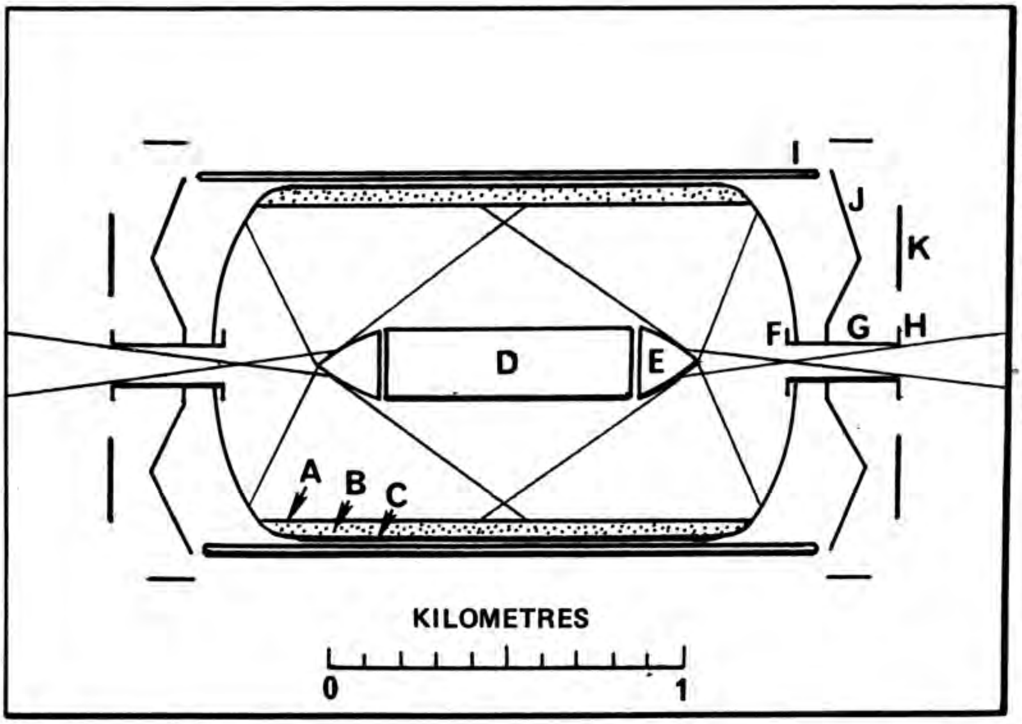


Fig. 2. Demeter cross section (minor structure omitted for clarity).
Key: A. Toroid inner window; B. Living/agricultural area (stippled); C. Outer shielding and hull; D. Zero-g/vacuum workshop; E. Light diffuser (2); F. Iris entrance closure; G. End hub (2); H. Outer entrance closure (2); I. Radiator, living area; J. Radiator, solar cell array (2); K. Solar cell array (2).

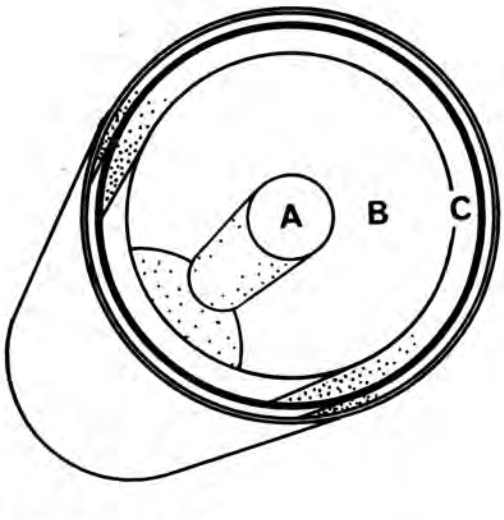


Fig. 3. Demeter: View of Interior.
Key: A. Zero-g/vacuum workshop; B. Void space; C. Living/agricultural area: thin toroid.

Table 1. Demeter: Elements and Dimensions.

Length overall, loa	1.63 km
Projected habitable length, l_p	1.40 km
Diameter to outer wall, d_o	1.00 km
Projected habitable area, A_p	4.40 km^2
Projected habitable area, A_p, per capita	440 m^2
Total surface area, A_t, cylinder + endcaps	5.12 km^2
Habitable volume, V_h	0.20 km^3
Total volume, V_t, cylinder + endcaps	1.17 km^3
Ratio, $\frac{A_p}{A_t}$, (Figure of Merit)	0.86
Mass, shielding, M_s, in metric tons, T_m	23.7×10^6 T_m
Mass, shielding, M_s, per capita	2370 T_m
Mass, atmosphere, M_a, (0.64 kg m^{-3})	128×10^3 T_m
Area illuminated, at 1/3 Sun	3.96 km^2
Area, each illumination mirror	0.66 km^2
Area, each power mirror (10% conver. eff.)	0.42 km^2
Watts, thermal, input for illumination	1785×10^6 W_{th}
Watts, elec., input for power (340×10^6 BTU per capita per annum)[4*]	113×10^6 W_e
Watts, thermal, to be dissipated by radiator	1900×10^6 W_{th}
Area of radiator for heat dissipation (Per Ref. 2, 20.8×10^3 W m^{-2} at 60% eff.)	9.13 km^2

* *Based on US consumption of all energy forms, 1970, Ref. 4. Since this figure includes conversion losses, heating and transportation requirements which do not apply to Demeter, the actual energy demand may be much less. Ref. 2, for example, assumes a habitat per capita energy requirement equivalent to 150×10^6 BTU per capita per annum.*

placed at either end of the cylinder. Light from the illumination mirrors is focussed inside the habitat shell and reflected from the end caps of the workshop. Mirrors are sized to provide a light intensity of 1/3 Sun. The focal point also affords a high-temperature source for the occasional smelting and refining of refractory metals. Other mirrors, peripheral to the illuminators but figured differently, provide a more diffuse light to the photovoltaic converters, two large torus-shaped solar cell arrays at the extremities of the cylinder hubs. Characteristics of these and other components of the habitat are listed in Table 1.

Finally, since all energy received as light and electricity must ultimately be dissipated by radiation, two means are

provided for getting rid of infrared heat. The solar cell arrays are backed up by reflectors, which may be panels of aluminium-rock wool sandwich material. In addition a wrap-around radiator, fitted with ducting for the circulation of habitat air, surrounds and shades the cylinder itself.

Habitat wall materials consist of a thin shell of aluminium overlaid by an opaque glass fibre cable fabricated from lunar regolith material, extruded in the form of glass filament and spun into cable. With the aluminium shell to serve as a mandrel, the glass cable is wound in cross layers under tension to a thickness of about two metres. When the entire habitat, including shielding, is rotated at 1.25 rpm, this layer of lunar glass serves both as structural member, sustaining the aluminium shell, and as radiation barrier, reducing radiation within the habitat to about 0.25 rem [2]. The overhead "roof" of the toroidal living/agricultural area is clear glass panelling set in aluminium frame. The appropriate material for this kind of glass appears to be lunar highland anorthosite from which opaque constituents have been extracted.

The dimensions of the habitat were selected to optimise the living/agricultural area with respect to the mass of the shielding material, which comprises by far the greatest mass requirement. Other design constraints are the g-loading of lg and the spin rate, 1.25 rpm, and the need to keep the toroidal configuration as thin as possible to minimise the mass of atmosphere. As noted, it will be necessary to provide as much as 60 kT_m of nitrogen from terrestrial sources. This severe logistical problem may be alleviated by substituting helium for part of the nitrogen.

A Figure of Merit for Shielding

In comparing the merits of alternate configurations, it is important to keep in mind that shielding mass (or its equivalent, A_t, the total surficial area of the circumscribed cylinder) should be compared to habitable area, A_p. In other words the ratio A_p/A_t should be as high as possible. This ratio approaches unity for a cylinder of infinite length, but since this is not a realistic case, we are going to define a Figure of Merit, F M, equal to A_p/A_t, and arbitrarily assign it a minimum value of 0.85. Since the radius of Demeter is fixed at 0.5 km by the spin rate and g-loading, the FM can be plotted against the projected habitable length l_p, to show the bounds within which l_p should fall, and establishing the major dimensions of the habitat (Fig. 4). A second variable, which it is desirable to maximise, is plotted on the same figure; this is the reciprocal of the total surface area, $1/A_t$. The intersection of the two curves at $l_p = 1.4$ is fortuitous, since it depends on the ordinate scales selected; nevertheless the l_p cannot depart widely from this figure without seriously compromising some design parameters. Accordingly the overall dimensions of Demeter are given the values shown in Table 1. This results in a generous area per capita of 440 m^2, distributed roughly as follows:

Table 2. Allocation of Living/Agricultural Area

	m^2
Residential	100
Agricultural	100
Community services and facilities	100
Community parks and recreation	100
Contingency and reserve	40
Total	440

The Figure of Merit, by this computation, has a value of 0.86.

Life Support and Life Style

A few other characteristics of Demeter are noted here:

The end hubs serve as entrances for docking space vehicles. Once the vehicle has entered, a cap moves into place over the outer opening, to protect the vehicle from the

Fig. 4. Demeter: Estimated length.

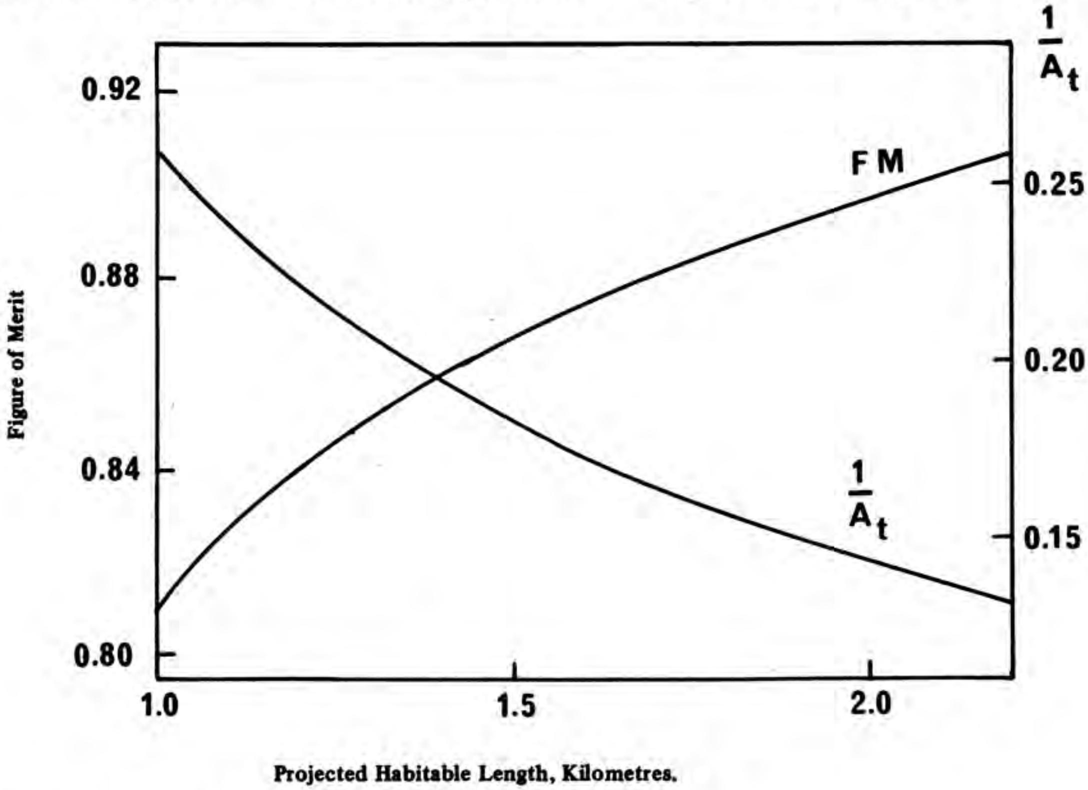


Table 3. Selected Elements for Three Habitat Configurations.

Configuration	m^2 per capita	Population	A_p, km^2	Volume, km^3 habitable	Atmosphere $T_m \times 10^3$	Shielding $T_m \times 10^6$	Shielding T_m per capita
Torus, large 1 g, 1 rpm $R_{maj.}$ = 830 m $R_{min.}$ = 65 m	67	10,000	0.68	0.069	44	9.9	990
Torus, small 0.85 g, 1.9 rpm $R_{maj.}$ = 209 m $R_{min.}$ = 27 m	35	2,000	0.071	0.003	1.9	1.0	500
Sphere, large 1 g, 1 rpm R = 895 m	67	75,000	5.03	3	1930	46.7	6200
Sphere, small 0.85 g, 1.9 rpm R = 236 m	35	10,000	0.35	0.055	35.2	3.3	330
Demeter 1 g, 1.25 rpm R = 500 m (comparison only)*	67	66,000	4.40	0.20	128	23.7	360
Demeter 1 g, 1.25 rpm R = 500 m	440	10,000	4.40	0.20	128	23.7	2370

* *This line compares Demeter to other models at same population density.*

intense heat of the mirror focus. These end caps can also be positioned to darken the interior and simulate night. At the inner hub opening an iris is located to give additional protection against cosmic radiation. This iris is opened when it is necessary to move large structures in and out of the central area.

The habitat rotates with its major axis perpendicular to the Sun line, and is allowed to precess while the lightweight mirrors rotate to face the Sun. The shielding is integral with the habitat and rotates with it, in contrast to the torus of Ref. 2, where hull and shield rotate in opposite directions at a differential rate of 100 m sec^{-1}. The integral design requires a substantial input of energy to get up to speed, but is inherently safer than the counter-rotating one.

Light, power and heat rejection are replicated by the dual mirror and radiation systems, so that adequate life support is assured in the event of massive systems failure.

The central workshop is used for pursuing vacuum and zero-g technologies. Other shops, ateliers and trades locations are within the habitat torus, mostly in the open – there is no need for protection against weather. It is likely, however, that a few internal bulkheads will be installed as a safety measure.

Some cultivars can best be grown under conditions, such as high humidity, that make it desirable to segregate them from residential areas, and from other crop areas as well – the essence of Controlled Environment Agriculture, whose methodology is the creation of special microclimates. Likewise some barnyard odours may be found objectionable in proximity to living quarters. Togetherness has its limits.

A Size Comparison

It is appropriate at this point to compare Demeter with other models. The configuration favoured in the NASA study [2] was, at least for early development, the single von Braun torus. The study also calculated habitat parameters for two sets of conditions, the preferred one having a rotation rate of 1 rpm at 1 g, the second a rotation rate of 1.9 rpm at 0.85 g. The latter is less desirable from the viewpoint of habitability, but would be much more readily constructed, since it requires only a tenth the shielding mass of the first. For this second condition, the Bernal sphere, with unshielded agricultural areas external to the central habitat, is reported as an attractive possibility. Table 3 compares the six forms, the large and small torus, the large and small sphere, and the Demeter with two population densities.

It appears from Table 3 that a minimal space habitat effort could be mounted using the small single torus configuration. To obtain early payoff from programmes for space power and manufacturing, this model should probably receive first priority. At a stage not much later, when high production rates of lunar materials have been achieved, more consideration must be given to the long-term comfort and well-being of the space settlers. New models will be sought embodying, for one thing, less crowded conditions, and it is then that a Demeter-like habitat may take its place in the skies.

Summary

A model for a Lagrangian habitat is presented which is believed to compare well to other proposed configurations. It is based on a much lower population density than most other models, resulting in a higher mass requirement, and consequently it is regarded as a second-generation concept. The large mass, however, consists of lunar materials which would require little processing except melting, extrusion and spinning into structural cable, to be wound about an aluminium hull. The resulting shape is an extended torus within a cylinder. The interior torus surface is a transparent glass, illuminated by external mirrors and internal reflectors.

Further development of the model is being pursued in the expectation that it will integrate, to a degree, residential and agricultural areas into a single complex of greenery, flowers, animal and possibly marine life forms.

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THE DIRECTION OF INTERSTELLAR EXPLORATION

By A. W. Orme

Introduction

Now that Man is embarking on space exploration, our thoughts turn to the probable pattern and direction of interstellar exploration. Specifically, we may ask the three questions posed by Strong [1]:

- *Towards which star....should Man's first galactic exploration set course?*
- *In which direction are we most likely to establish radio communication with another intelligent race?*
- *Which is the most favourable direction in which to expand as a race into the stars with the object of meeting other star-faring people?*

We may meet indigenous races on any stellar system we visit. However, as we are contemplating interstellar exploration, we may inquire as to whether we are likely to encounter alien races undertaking the same. We should only meet aliens if our paths cross, so we may legitimately ask if our Solar System, or any of the stars we are likely to visit, are on the way from anywhere to anywhere.

The first three questions above were posed by Strong in 1970, who examined stellar charts and detected concentrations of suitable stars for exploration in the constellations of *Eridanus* and *Ophiuchus.* A more rigorous approach is now required, for three reasons:

1. To make a more reliable estimate of the direction of interstellar exploration, including as many relevant factors as possible;
2. To extend the analysis to a greater distance than that considered by Strong;
3. To attempt a satisfactory answer to the fourth question above: are we, or our likely destinations, on the list of likely destinations of others?

One does not need great astronomical expertise to realise that the first star Man is likely to visit is *Alpha Centauri,* a double stellar system with G2 and K0 type suns, both similar to our own, and the nearest system to us. After that, the pattern of exploration is not readily predictable and a conceptual model is required.

The Model

Man's exploration of the Universe is seen as a slow outward expansion, star-hopping because of the immensities of distance before us. As each new solar system is conquered, Man will select new targets further from the Sun. In this model paths will be assessed which lead from the Solar System to hypothetical spherical shells of several light-years in radius: each increase in radius represents a further penetration of space. The attraction of different stellar systems to would-be explorers is arrived at by partly using the relevance factors of Archer and O'Donnell [3]. The latter considers relevance to stellar evolution, autotrophic life forms and heterotrophic life forms as valid reasons for exploring different worlds; but it is doubtful whether stellar evolution is sufficiently important to lead to colonisation of a surrounding system, and to introduce the possibility of advanced heterotrophs is to admit the possibility of life just about anywhere. We are left with the relevance factor for

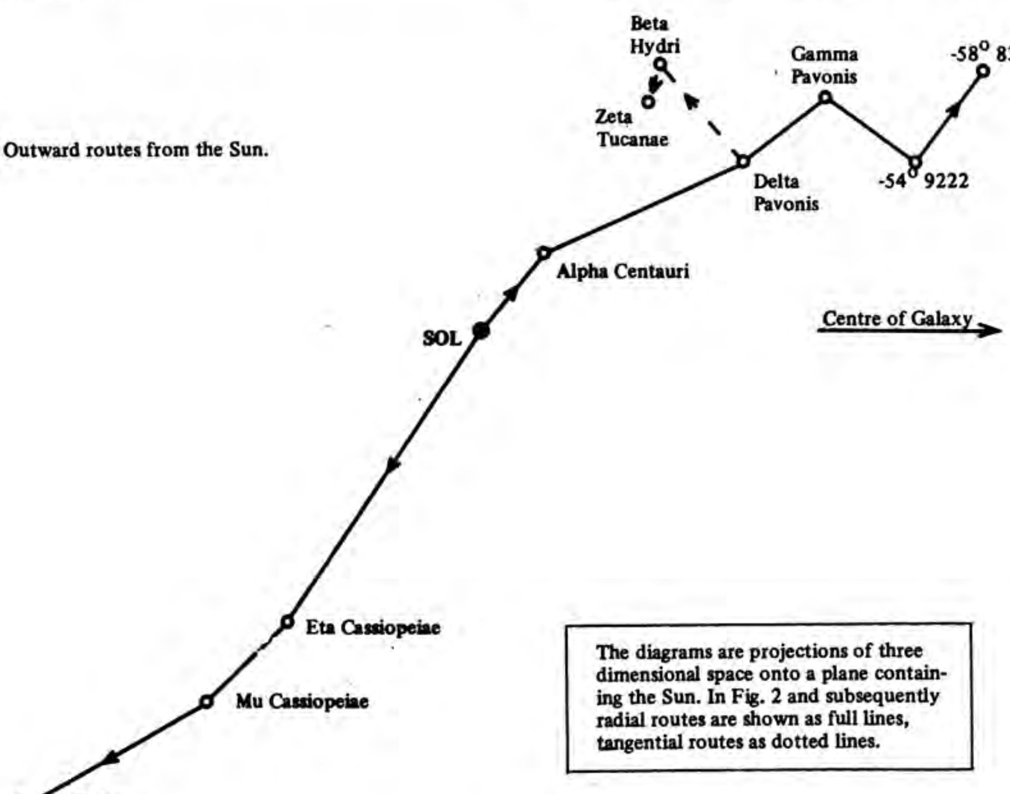

Fig. 1. Outward routes from the Sun.

The diagrams are projections of three dimensional space onto a plane containing the Sun. In Fig. 2 and subsequently radial routes are shown as full lines, tangential routes as dotted lines.

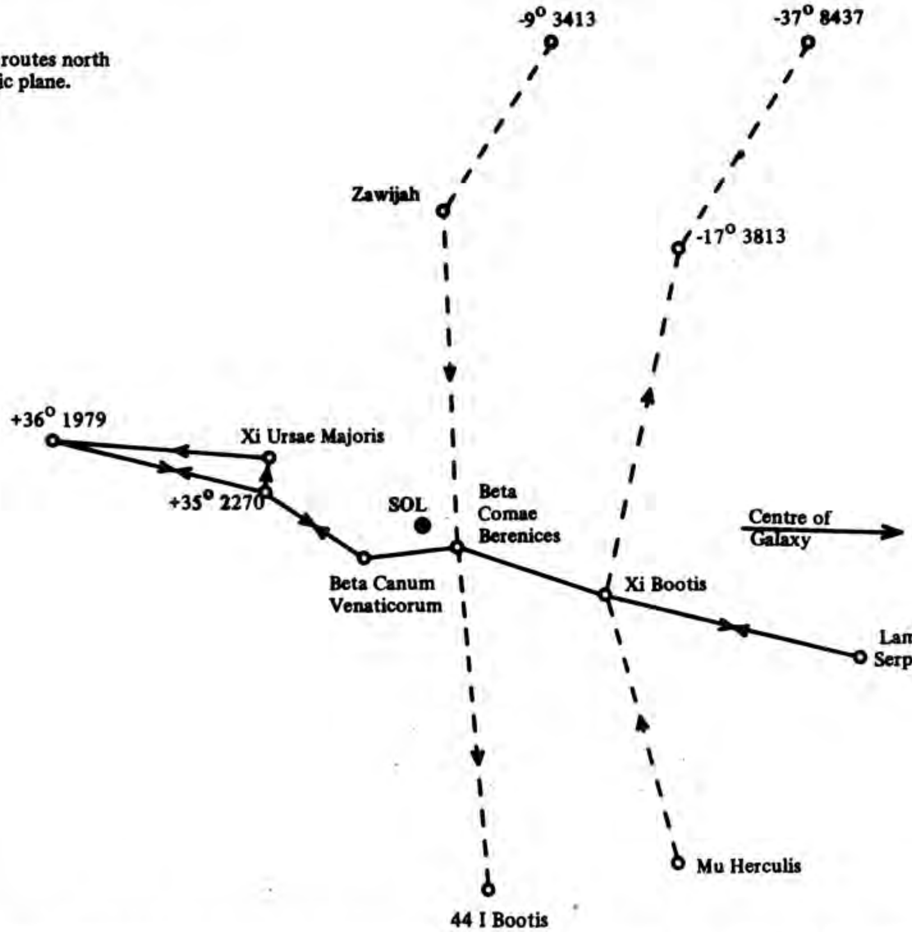

Fig. 2. Major routes north of the Galactic plane.

autotrophic life forms, which is based on the probability of habitable life as assessed by Dole [4]. Also in our model, it is considered that the attraction of a potential exploratory target is diminished by the square of the distance, analogously to the Demographic Law of Gravitation proposed by Stewart [2] after studying movements of population between cities of the U.S.A.

Extension of the model to cover the activities of any spacefaring aliens is more problematical in that we do not know a starting point. However, we do know that the Sun lies about two-thirds of the way out of a disc-shaped galaxy, the ratio of whose diameter to maximum thickness is approximately ten to one. The stellar density is very much greater at the centre of the Galaxy than in our region of space. Accordingly, if an exploration of space were being conducted from a stellar system further out of the Galaxy than we are, it would most likely be directed toward the centre, where stars are most plentiful and the potential rewards highest; if conducted from nearer the centre than we are, it is conceivable that an alien race or stellar federation might have reasons for pushing radially outwards or tangentially to the radius vector (in the plane of the Galactic disc). There is unlikely to be much interest in travelling in the direction perpendicular to this plane, where the stars peter out and give way to the intergalactic void.

Similar considerations apply to the Gould Belt, the Local System of which our Sun is a part and which forms an arm of our Galaxy. The most important direction is to and from the centre of the Belt.

To represent the above exploration system we shall consider a series of hypothetical cubes of space, with sides parallel to the Cartesian axes of the Galaxy or the Local System as appropriate. For convenience, the Sun is made the centre of each cube, although the centre otherwise has no special significance.

A model embodying the above features was implemented on a B6700 computer. A network-handling algorithm was employed to solve for the paths of least reciprocal of attraction, i.e. to minimise $\Sigma d^2/P_{HP}$ for a network, where P_{HP} is the probability of habitable planets around a destination star by Dole, and d is the distance between any two consecutive stars on a given path. Boundaries are assumed to have a P_{HP} equal to the average for the stars under consideration.

Results

Dealing first with the exploration of stellar space by Man, it is found that there exist two main routes for expansion (Fig. 1). The best lies toward the main body of the Galaxy at about 55° to the radius vector, and comprises in this order the very interesting double system of *Alpha Centauri*, the attractive *Delta Pavonis* (G8 type sun) and *Gamma Pavonis* (F8), the double system -54° 9222 and the attractive -58° 8327(G4). There is a possible branch from *Delta Pavonis* to *Beta Hydri* (G1) and *Zeta Tucanae* (G2), both interesting stars and having several stars of lesser significance relatively close by. The second route for expansion lies away from the centres of the Galaxy (in fact at 50° to the radius vector) and the Local System (also at 50°). It goes through three individually attractive stellar systems, *Eta Cassiopeiae* (double, G0 and M0), *Mu Cassiopeiae* (also double, G5 and spectral class unknown) and +41° 328 (G2). This route finishes 38 light-years from the Sun, as against 47 for the first route given.

It should be noted that uncertainties in the measurement of parallax generally increase with parallax, so that there is little point in extending the analysis over vast regions of

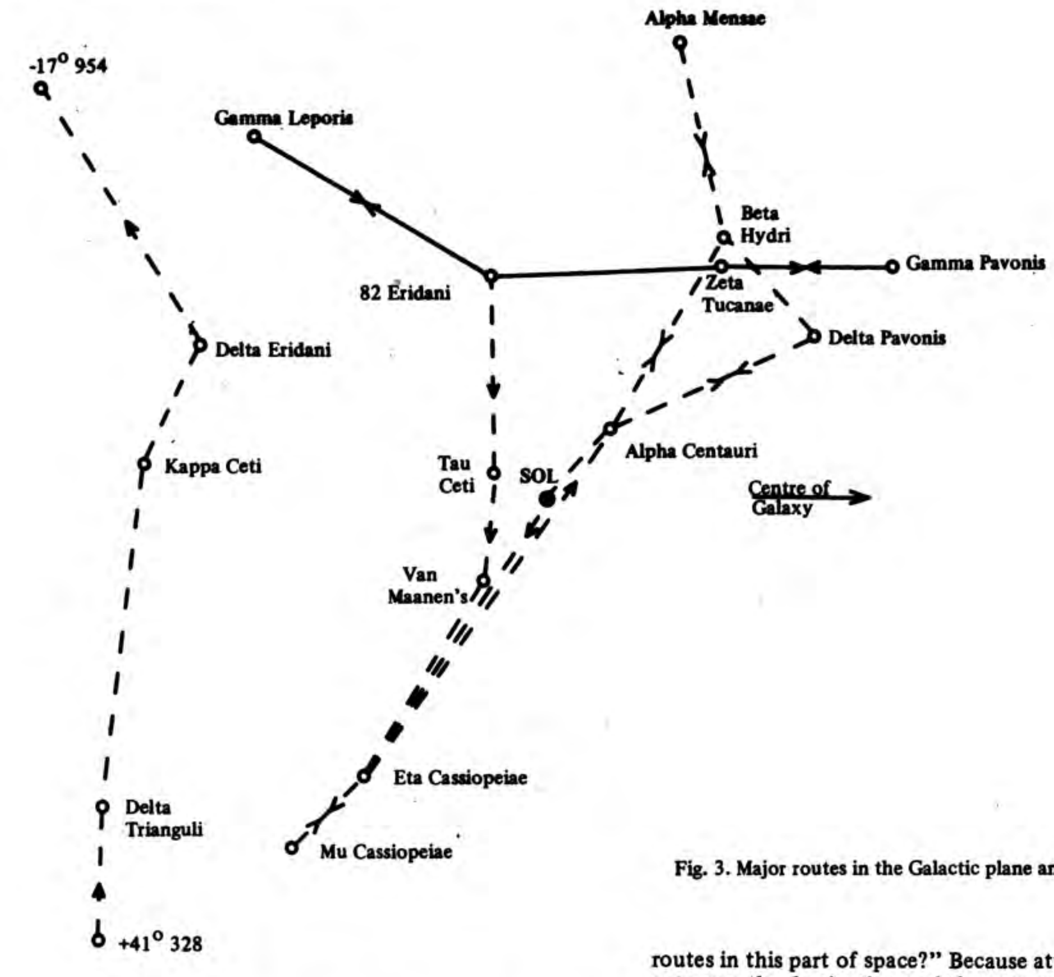

Fig. 3. Major routes in the Galactic plane and south of it.

space: the largest sphere analysed was about 57 light-years in radius, and toward the edges of that there must be considerable doubt over the precise position, number and other attributes of stellar systems present.

Investigation of cubes of space was prompted by the question, "Are We on the Way to Anywhere?", and the question that follows from it, "What, if any, are the natural routes in this part of space?" Because attraction is dependent upon the destination and the square of its distance, the direction of travel between opposite sides of the hypothetical cube has important effects.

Consider the diagrams of routes referred to the plane of the Galaxy (Figs. 2 & 3). They naturally fall into two groups and have been separately mapped because they

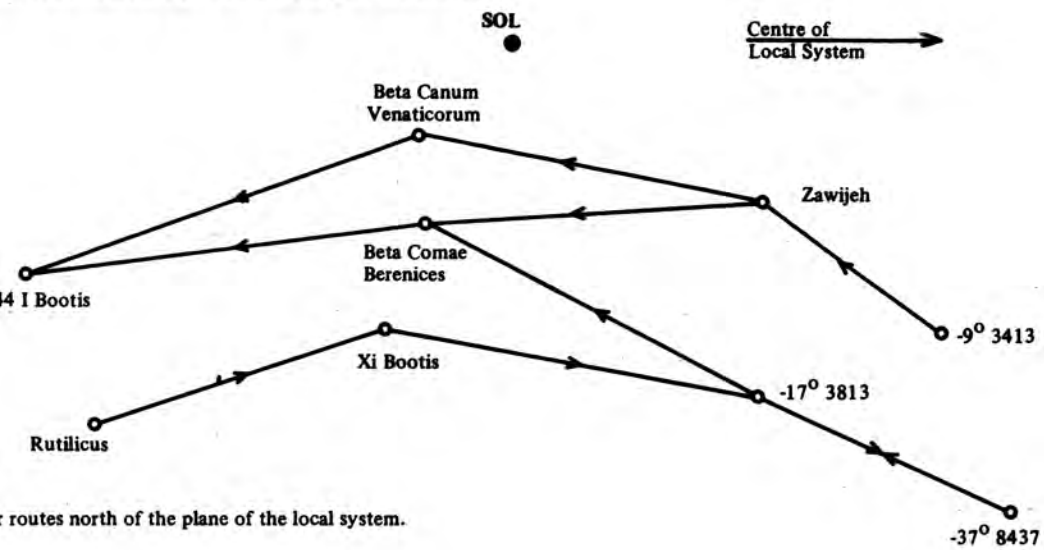

Fig. 4. Major routes north of the plane of the local system.

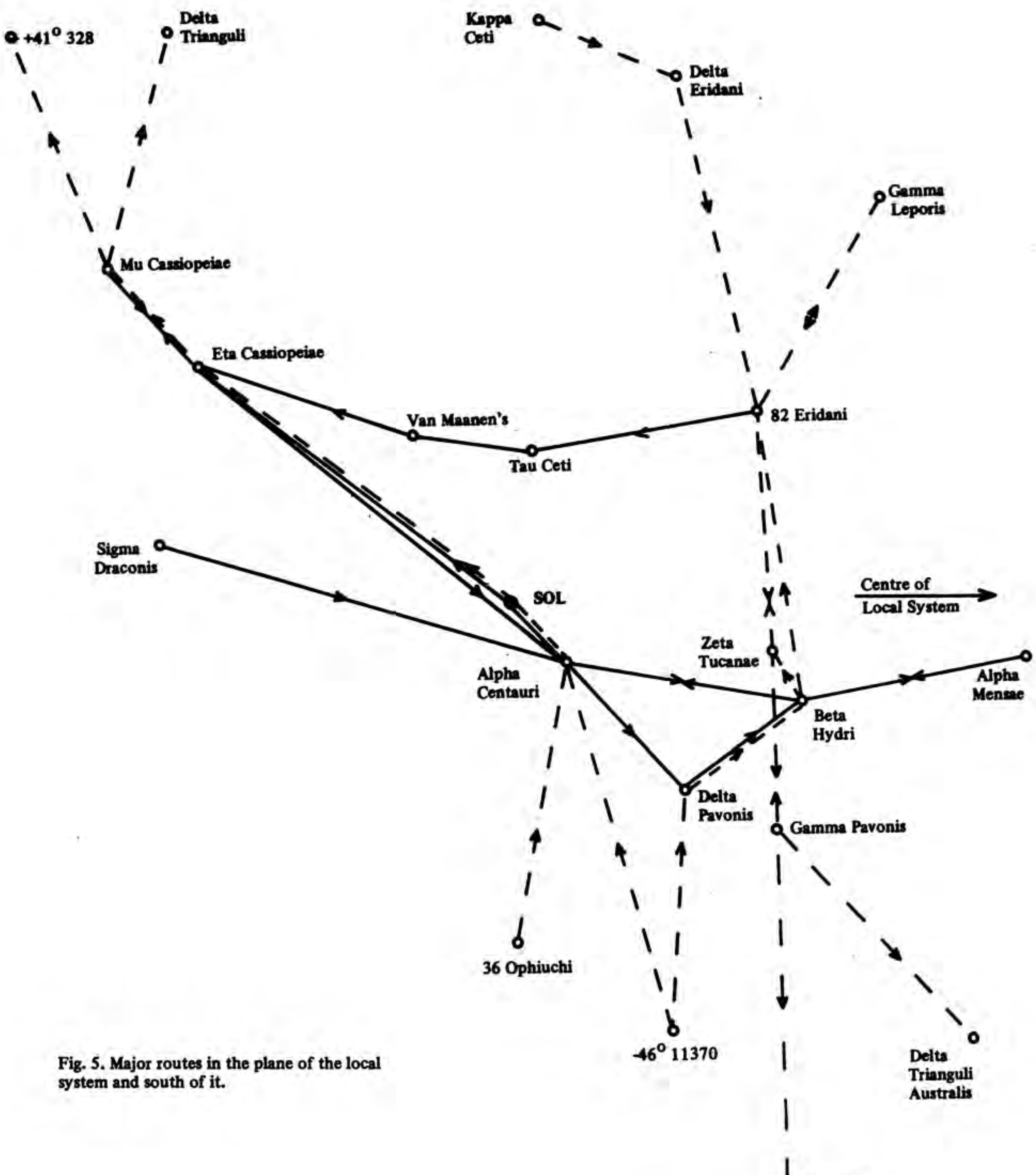

Fig. 5. Major routes in the plane of the local system and south of it.

would otherwise overlap. The best route towards and away from the Galactic centre in fact lies in a region between 20 and 30 light-years North of the plane of the diagrams, which latter include the line between the Sun and the Galactic centre. This route, or at least the part here discovered, goes from +36° 1979 to *Lambda Serpentis*, and incorporates two stars on other routes, *Beta Comae Berenices* and *Xi Bootis*. These other two routes lie tangential to the Galactic radius vector, and one of them contains the double star system 44 *I Bootis* (Spectral types G1 & G2), noteworthy for being more suitable for life than *Alpha Centauri*, although nine times more distant.

Nearer the Sun, the only good route for radial travel is one lying between *Gamma Pavonis* and *Gamma Leporis*, suitable for travel in both directions. However, there are no suitable "lead-ins" to the end-members from outside of the space investigated. Clearly, the Solar System is not on the schedule of anyone travelling to or from the Galactic centre, provided the initial assumptions are correct.

There are several routes tangential to the radius vector and close to the Sun. In particular, the route going from *Alpha Mensae* to *Mu Cassiopeiae* passes through the Sun in one direction, while in the other leads directly from *Eta Cassiopeiae* to *Alpha Centauri*. Since the centre of the Local Sys-

tem lies beyond the tops of Figs. 2 and 3, it follows that the Solar System may be in the path of any travellers leaving the Local System centre tangential to the main Galaxy.

The last conclusion is reinforced by examination of Fig. 5. Here, calculating directions referred to the Local System centre, it is found that the path from *Alpha Mensae* to *Mu Cassiopeiae* is still suitable for travelling and that the Sun lies on the outward path of it. This route ranges between 0 and 13 light-years South of the plane of the diagram. From Figs. 3 and 5 it may be seen that important "junctions" of paths exist in *Alpha Centauri, Eta Cassiopeiae, Zeta Tucanae, Beta Hydri* and *82 Eridani.*

In Fig. 4 it may be seen that again for travel with respect to Local System directions the North offers the best routes. These routes lie between 12 and 28 light-years North of the plane of the diagram and, as mentioned before, contain 44 *I Bootis.*

The results here obtained differ somewhat from those of Strong (*op. cit.*). The reason is partly due to the method, and partly to the severe criteria for assessing habitability of alien solar systems by Dole. Some may object that the latter show evidence of heliocentric thinking and may not be appropriate anyway when considering habitability for aliens; more research is required in this area.

Some mention has been made recently in the semi-technical press of the possibility of using black holes as short-cuts over vast distances in space. Although no black hole has been discovered in this sector of the Local System, if some were discovered and the theory substantiated then the methods of this article could be used to throw light on the questions asked above: the distances used, of course, would be the "short-cut" ones (i.e. *via* the black hole). In the meantime, there is much uncertainty as to the properties of our nearest stellar neighbours, and few if any of the conclusions arrived at here can be regarded as definite until more precise data is released from the world's astronomical observatories.

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MILESTONES *[continued from page 386]*

the Baikal-Amur-Railway have been photographed from space, "greatly easing the task of assessing the timber wealth of Siberia and the Soviet East". Comprehensive area of the images show the area and number of trees, their species, age and quality of their timber. A big woodworking complex is being built in the Ust-Ilim, on the River Augara, to process timber on the spot including half a million cubic metres of sawn timber and a quarter of a million tons of hardboard a year, as well as yeast, turpentine and resin.

22 Talks between the USSR and the United States in Vienna on banning hunter-killer satellites end inconclusively after eight weeks.

28 Soviets launch automatic cargo craft Progress 7 from Tyuratam at 12.25 hr. (Moscow time).

28 NASA postpones first launch of Space Shuttle 'Columbia' until late March 1980 at the earliest. According to NASA internal forecast, there is only a 20 per cent chance of meeting this data, with late June as a better—50 per cent—probability. FY 1980 budget, even with extra $220 requested by NASA, may be insufficient to support a launch as late as June. Earliest the Shuttle could be declared operational, following four or five test flights, is September 1981, an exceedingly tight schedule. Certain payloads already scheduled for Shuttle launches may have to be transferred to expendable boosters.

30 Progress 7 docks with Salyut 6 on aft airlock at 14.18 hr. (Moscow time), delivering fuel, experimental equipment, food and mail.

July

2 Second static test of a clustered Space Shuttle Main Engine (SSME) at Bay St. Louis is halted after about 20 seconds of a planned 520 sec burn because of rupture of the main fuel valve of one of the three engines. NASA reported that seven of 21 bolts securing a cap on the valve broke releasing high-pressure hydrogen which damaged test stand. Apart from the valve, the three engines were virtually undamaged. However, repairs to test stand could delay further test firings until mid-September. The valve in question had been used 55 times and had accumulated more than 8,000 seconds of test time.

4 European Space Agency announces that work has started on modified Sled experiment to test human responses to small linear accelerations aboard Spacelab. Marshall Engineering (UK) will supply mechanical sub-system; Bell Telephone (Belgium) electrical sub-system. Two Sled units will be built, a crew training model and the flight model.

5 External Tank for Space Shuttle 'Columbia' arrives by barge at Cape Canaveral. It left NASA's Michoud facility near New Orleans on 29 June.

6 Soviets launch Gorizont (Horizon) 2 TV-relay satellite by Proton rocket from Tyuratam into synchronous orbit.

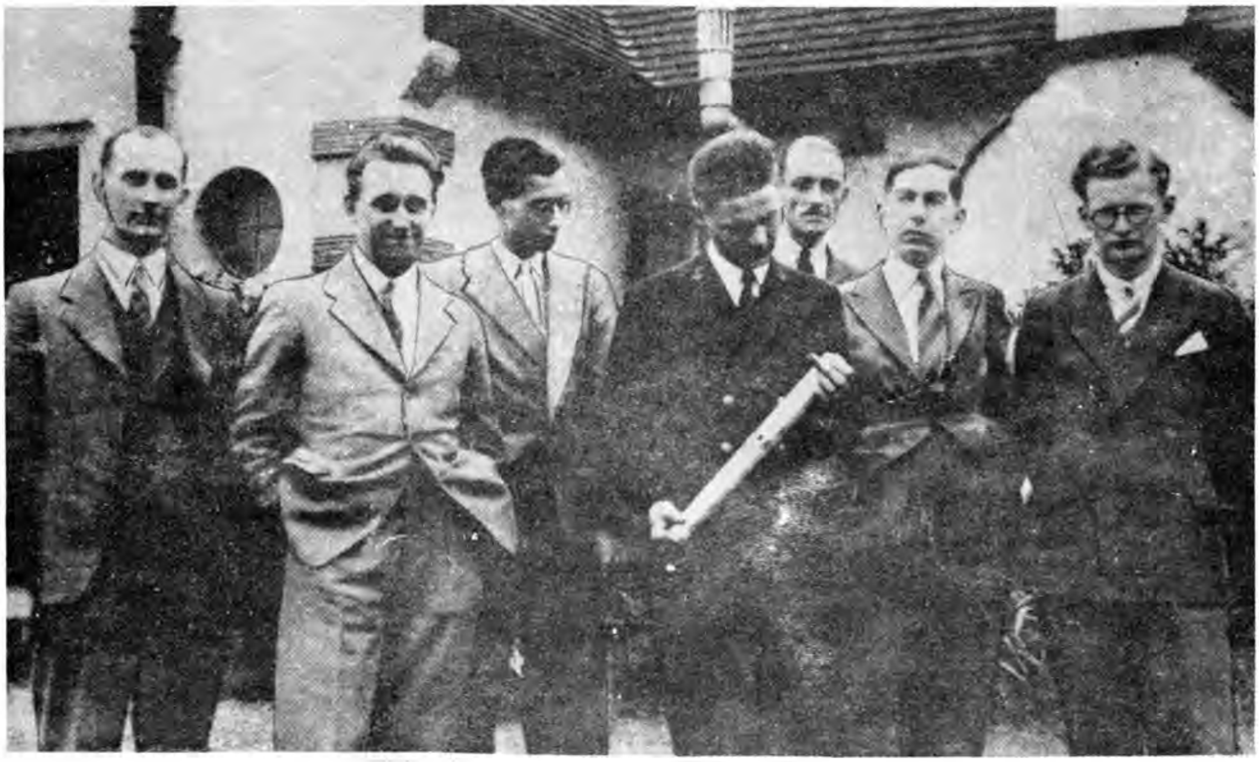
8 Soviets reveal that Progress 7 has been used to push Salyut 6 space station complex into an orbit of unprecedented altitude – 399 x 411 km.

9 Voyager 2 passes within 650,180 km of the visible cloud tops of Jupiter on gravity-assist mission to Saturn and possibly Uranus. During period of close encounter four Galilean moons – first photographed in detail by Voyager 1 in March 1979 – were re-examined from different aspects. Voyager 2 passed within 200,000 km of Europa photographing cracks in ice crust some nearly 5,000 km long and up to 50 km wide; also was able to observe Io for some 10 hours recording several volcanic eruptions. Face of Jupiter was seen to have changed appreciably since Voyager 1 encounter, e.g. vortices circulating around Red Spot no longer reached to the edge of this

[continued on page 425

THE BRITISH INTERPLANETARY SOCIETY 1933-1979

By G. V. E. Thompson



MEN OF DESTINY. *Left to right,* Harry E. Ross; J. Hapien Edwards; – Turner; Midshipman Robert C. Truax (visiting from the United States); Ralph A. Smith, M.K. Hanson and Arthur C. Clarke. Collectively and individually, these people were to make an immense impact upon the future of Astronautics. British members of the group established the basis for moonflight between 1937-39 in the world's first engineering study of a manned vehicle capable of soft-landing on the Moon; Arthur C. Clarke introduced the concept of communications satellites in geo-stationary orbit and through his writings has contributed hugely to the theory, practice and philosophy of Astronautics. Robert Truax made outstanding contributions to the development of rocketry in the United States. (In the picture he is holding one of his early rocket motors). This photograph —now on display in the National Air & Space Museum in Washington, D.C.—was taken in July 1938.

Early Days

The Society was founded in October 1933 by Philip E. Cleator, a Cheshire businessman and was based at Liverpool for the first three years of its existence. Its declared purposes were to study the possibility of interplanetary travel, to report work on rocketry throughout the world, and even to undertake experimental work in Britain. Publication of a Society *Journal* was planned and the first issue appeared in January 1934.

The formation of the Society was received kindly by the Press on the whole, though there seem to have been certain lapses for the Society's President soon had to deny the possibility of wishing to annex Mars for the British Empire in the non-too-distant future! He also reported that the Air Ministry had evinced not the slightest interest in the Society's activities in promoting the development of rockets, the Under Secretary of State at that time having replied (1934):-

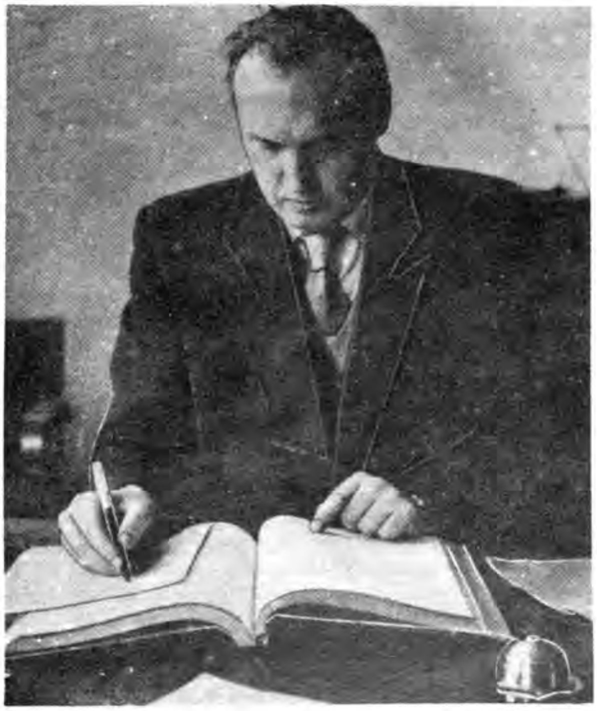
> *"We follow with interest any work that is being done in other countries on jet propulsion, but scientific investigation into the possibilities has given no indication that this method can be a serious competitor to the airscrew-engine combination. We do not consider that we should be justified in spending any time or money on it ourselves."*

So this left our Society as the only body in Britian studying in this field of knowledge. Membership grew slowly but steadily, the British members enrolled at this period including many later Presidents or Chairmen of Council: A. C. Clarke, Professor A. M. Low, L. R. Shepherd, and R. A. Smith. Foreign members included rocketry experts from the U.S.A., Germany, Russia and Austria.

One or two of the new members regarded the word "interplanetary" as fantastic and demanded, in October 1934, that the Society's name be changed to "Institute of Rocket Engineers" or to the "Society of British Rocket Engineers". This proposal was rejected by the BIS Council of that period, for the reason that the Society's objective was interplanetary travel, with the rocket as only the means to that end.

With hindsight, we see that this was a wise decision, for only 22 years were to elapse before interplanetary travel was to become a reality. Nevertheless, this seemed very far away in the Society's early days and spasmodic attempts to change the name of the Society recurred subsequently.

A London Branch of the BIS was formed in 1936 and in the following year it was decided to transfer the Headquarters to London. A Technical Committee was set up to study all aspects of astronautics with the reports of its deliberations published in the Society's *Journal.* Probably the most significant achievement in this period was the publication, in the January 1939 issue of the *Journal,* of a paper on "The BIS Space-Ship" by H. E. Ross. This described a design departing radically from all previous suggestions and incorporating ideas whose subsequent development have led to the space-



Len Carter, BIS Executive Secretary since 1946.

Our former headquarters at 12 Bessborough Gardens, London, soon to be demolished under a redevlopment scheme. (The Society occupied two L-shaped rooms on the ground and first floors).

craft of today, such as Apollo and Soyuz. A more detailed description of the proposal appeared in the July 1939 issue.

Quiescence

The first phase in the Society's history ended shortly afterwards with the outbreak of World War II in September 1939. Many of the younger members entered the services and older members took up classified work. Conditions were unsuitable for holding meetings or for publishing, particularly since the subject soon began to show obvious military applications. The BIS therefore went into abeyance until hostilities ended, although a few local groups found it possible to meet from time to time.

Rebirth and Rapid Growth

As soon as the war ended, the BIS was reformed, all the local groups being merged into the new body. It was decided to seek an official incorporation under the Companies Act and this took effect on 31 December 1945. Mr. L. J. Carter was appointed Secretary, a post he has occupied with distinction ever since. The subsequent growth and achievements of the Society owe much to Len Carter's devoted and near-herculean activities.

For a few months the Society was limited to publishing a duplicated *Bulletin*, but as membership grew it became possible to have it printed. Publication of the *Journal* was also resumed. For a year or so both periodicals were issued, until it was decided to concentrate the Society's efforts on the senior publication. So the *Bulletin* was dropped, after a useful but rather short existence.

The journals now being issued were much more professional publications than the pre-war issues, both as regards production and content, and their standard continued to improve. Mathematical papers on subjects such as interplanetary flight and rocket combustion began to appear. An important source of contributions to the *Journal* were the monthly lectures, held first at St. Martin School of Art and later at Caxton Hall, but many others were specially written for publication. Only a few papers can be mentioned here: "The Atomic Rocket" by L. R. Shepherd and A. V. Cleaver, "Interplanetary Man" by Olaf Stapledon, "Orbital Bases" by H. E. Ross (dealing with the establishment and design of space stations), "Lunar Spacesuit" by H. E. Ross, "Perturbations of a Satellite Orbit" by Lyman Spitzer, and "The Man-Carrying Rocket" by R. A. Smith. The latter was a proposal for converting a captured V2 rocket to carry a man, to enable the first manned sub-orbital space flights to be made. The proposal was put before the Air Ministry but no action resulted. More than a decade was to elapse before Shepard and Grissom made such flights with a Redstone rocket in the USA.

K. W. Gatland, A. M. Kunesch and A. M. Dixon presented a series of composite papers in 1950-51: "Initial Objectives in Astronautics", "Orbital Rockets", and "Minimum Satellite Vehicles", in which they considered useful astronautical projects, short of manned space flight, which could be accomplished with the then existing rocket propellants and engineering practice. Their third paper had four schemes for vehicles which should be able to put into orbit around the Earth the minimum satellite payloads capable of providing useful scientific information. A connection has been traced from this work to the first U.S. artificial satellites (*Spaceflight*, May 1979, p. 227).

This last paper was presented at the most ambitious activity the Society had up to then attempted – a week-long Symposium on Satellite Vehicles held in London in 1951 and attended by representatives from all the world's rocket and astronautical societies. The Symposium was held in conjunction with the Second International Congress on Astronautics. On the initiative of the German, French and British societies, the first Congress had been held in Paris the previous year, when representatives from bodies (including the BIS) had discussed the possible formation of an international organisation. This was formally established at

Post-war group featuring two past-Presidents–the late R.A. Smith *(centre)* and the late Professor A.M. Low *(right)*.

the London Congress as the International Astronautical Federation (IAF). As host-society, the BIS was naturally a founder-member of the IAF: as will be seen later, our Society has continued to participate actively in the work of the IAF by providing papers for the annual Congresses, sending delegates to its business and other sessions, and by making substantial financial contributions towards its running expenses.

Another important development occurred in 1952. Up to then the Society had had to operate from private addresses, but on 12 May 1952 moved into offices at 12 Bessborough Gardens, London, SW1 as tenants of the Queen and her government – or more precisely, of the Crown Agents. The accommodation was modest – just one L-shaped room – but it enabled the Society to employ a permanent staff of one and – at a pinch – to hold committee and Council meetings on its own premises. As the membership grew steadily, it proved possible to acquire an

Dr. L.R. Shepherd *(right)* presents a painting from the Society to Sir Roy Dobson, in recognition of support to the Society from the Hawker-Siddeley Group.

addressing machine and other office equipment to improve the secretariat.

About this time Dr. L. R. Shepherd read a paper on "Interstellar Travel" thereby demonstrating that our interest in space had no limitations. But more pressing problems were not neglected. The design and testing of rocket motors of various kinds received considerable attention, as did the mathematics of transfer between different orbits, food and atmosphere control in space vehicles, landing on airless planets, a lunar base, and a host of other topics. Dr. W. R. Maxwell of the Rocket Propulsion Dept., Westcott gave demonstrations of the properties of rocket propellents (for obvious reasons, these were given at the Regent Street Polytechnic rather than the usual venue of Caxton Hall). In addition, groups of members paid visits to Westcott and to other establishments.

As these visits necessarily took place during working hours, many members were unable to take advantage of them, but they could do the next best thing – attend the Film Shows, which the Society organised regularly. The subjects of the films screened included rocket development, guided missiles, nuclear energy, astronomy, etc.

Several local branches existed at this period – in the North-West, Midlands, Yorkshire and Bristol. For a time they flourished successfully, but most had a rather chequered career and their activities eventually suffered from lack of local support. A successful branch requires both a nucleus of keen and dedicated members willing to give up their time to organise local activities, and sufficient members or potential members in the area to provide an adequate audience or discussion group at meetings. The success of a branch has often been linked with the presence of an Aerospace plant in the region and closure or contraction of such a plant can lead to collapse of a branch due to insufficient support. However, the Council has continued to support local activities wherever these seemed to be viable.

Besides these "internal" activities, leading members of the BIS at that time embarked on "missionary" action to bring knowledge about astronautics (and the work of the BIS) to the general public. This was done by means of books, magazine and newspaper articles, occasional radio programmes, and above all by several thousand public lectures given to scientific or social organisations, schools, etc. Common fallacies and misconceptions about interplanetary travel were gradually dispelled, interest in the subject was awakened, and, in the early 1950's the Society's membership rose rapidly.

Rockets were now being used extensively to explore the upper atmosphere. In August 1953 an important conference on this subject was organised by the Royal Society at Queens College, Oxford. About half the BIS Council attended and participated in the discussion. Of the papers presented, the most significant now seems to be that of Professor S. F. Singer of Maryland University, who developed the ideas of Gatland, Kunesch and Dixon (mentioned above) and proposed the MOUSE satellite vehicle (Minimum Orbital Unmanned Satellite Earth) concept and identified many of the applications for which the 100 lb satellite would be suitable – for studying solar radiation, cosmic rays, weather, etc.

Although the Society's eyes were directed firmly towards the future, the past was not neglected. As World War II receded into history, secrecy was relaxed and it became possible for the *Journal* to publish valuable accounts by German engineers, such as Riedel and von Braun, describing early rocket experiments and the development of the V2 and other rocket weapons. Data sheets were printed on existing rocket vehicles and engines.

It is impossible to mention here all the topics covered in the Society's *Journal* at that time – suffice to say that they dealt with all aspects of space flight, often in considerable

detail. Some of the topics have since become matters of fact; others (such as extraterrestrial mining or farming) have still to be put into practice. Two series of mathematical papers – those of Professor Lawden on correction and perturbation of interplanetary orbits, and those by D. G. King-Hele on descent of earth satellites through the upper atmosphere – were providing the theory which would be needed in the forthcoming work with artificial satellites.

In July 1955 the U.S. government announced an artificial satellite programme, which would be linked with the International Geophysical Year (IGY), due to commence in July 1957. The BIS began to organise "Moonwatch" and radio tracking teams to observe the satellites (it should not be forgotten that this was before the establishment of massive and very expensive governmental tracking stations – the giant radio telescope at Jodrell Bank was in construction but had run into engineering and financial difficulties). At the Copenhagen congress of the IAF (August 1955) the USSR also announced interest in artificial satellite plans, though little information was given as to what would happen.

This led to an increase in the public awareness of astronautics and Council judged the time right for the issue of a popular magazine. *Spaceflight* commenced publication in October 1956, initially under the editorship of Patrick Moore, the well-known amateur astronomer and author. A book "Realities of Space Travel" which contained twenty-four of the best papers from the Society's *Journal* appeared as a book edited by L. J. Carter and was an immediate success. Len Carter had edited the Society's *Journal* since March 1947, besides being the Society's Secretary, but in view of the great increase in secretarial work he now had to relinquish the Editorship, G. V. E. Thompson taking over instead.

The Society had always had two grades of membership: ordinary Members (who merely wished to keep in touch with current developments) and Fellows (who had an appropriate degree or other qualification and were interested in the detailed technical aspects of the subject). In response to requests, two new grades were now introduced: Senior Membership (for members of long standing) and Corporate Membership (for firms and organisations).

Other Societies and educational establishments were now finding that certain aspects of astronautics were having an impact in their own fields, so it was opportune to hold joint symposia with the BIS on appropriate topics. The first of these was the Symposium on High Altitude and Satellite Rockets organised jointly by the BIS, the College of Aeronautics, Cranfield, and the Royal Aeronautical Society and held at the College in July 1957. Details of the U.S. satellite programme were given and a Russian delegation attended.

Dawn of the Space Age

On 5 October 1957 as delegates (including a strong BIS contingent) were travelling to Barcelona for the eighth IAF Congress, there came the news of the launching of the first Russian Sputnik. The Space Age had begun! Astronautics captured the imagination of press and public for what had yesterday seemed fantasy had now become fact. Activity increased in all branches of the Society's work.

In 1958 the Society was twenty-five years old. This special anniversary was celebrated at a banquet at the Waldorf Hotel, held in conjunction with an International Symposium on Space Medicine and Biology organised by the Society and held in the Great Hall of the British Medical Association. The voyage of the dog Laika in Sputnik 2 had indicated that manned space flight would not be long in coming and so this symposium was well attended. Three of the papers presented were from the RAF Institute of Aviation Medicine and a strong team from the U.S. Office

Reception area at the 10th IAF (London) Congress.

River trip organised for delegates to the 10th IAF Congress organised by Air BP.

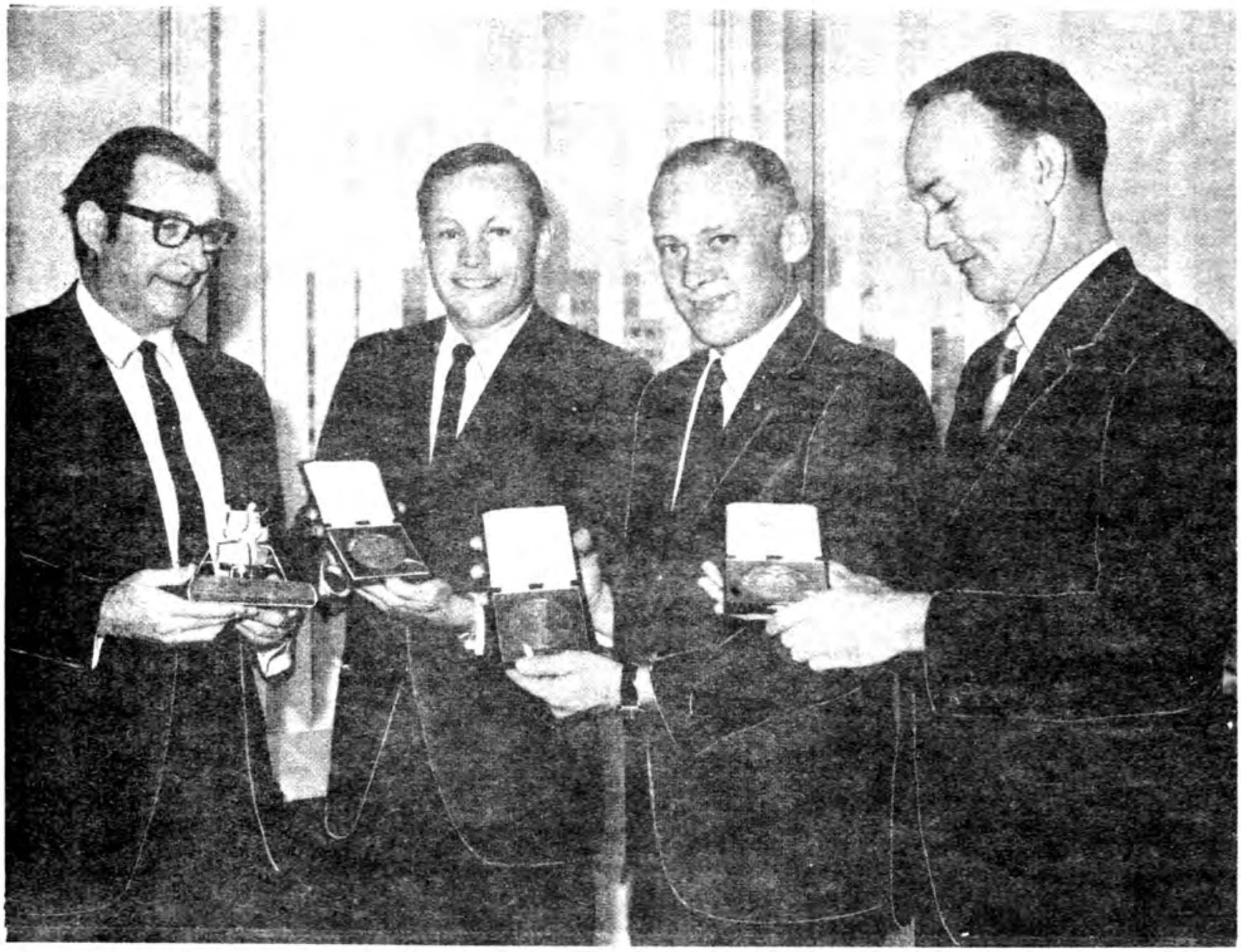
of Naval Research also discussed their work. The early unmanned satellites had given valuable results, one interesting discovery being the van Allen radiation belts around the Earth.

The following year (1959) was an exceptionally heavy one for the Society. In addition to the ordinary load of publishing and meetings, the BIS was again host-Society to the IAF and organised the Tenth International Astronautical Congress at Church House Westminster. The Society, at last, received a good measure of Government support, the Congress being opened by the Minister of Supply and with delegates invited to a reception at Lancaster House. Eighty-one papers were read at the Congress, and as if that were not enough, a Space Law Colloquium was held in parallel at Lincoln's Inn and the whole was preceded by a three-day Commonwealth Space Flight Symposium which surveyed work going on in the British Commonwealth. Proposals were made for the establishment of a joint Commonwealth Space Agency, though these came to naught.

The page size of the *Journal* was increased to that of *Spaceflight* at the beginning of 1959. Both were bi-monthly publications but their production was interrupted after a few months due to troubles in the printing industry. Such troubles have continued through to the seventies, at intervals, though their loss and effects have usually been cushioned by prompt action by the Council and our Staff, a fact not always known to members or readers in general, for we should mention that many libraries, firms, etc., subscribe to our publications.

From time to time the Society has taken a political initiative whenever it thought this might be effective. On 2

Presentation of Silver Plaque to the original Mercury Team: *Left to right*, L. J. Carter and Dr. L. R. Shepherd (BIS), Alan B. Shepard, Gordon Cooper and "Gus" Grissom (astronauts).



Cheerful group: Dr. G. Paine (*left*, holding the Society's silver replica of Apollo 11 presented to NASA) and Neil Armstrong, Edwin Aldrin and Michael Collins, (holding Society gold medals), in recognition of the triumph of Apollo 11.

Presentation of the Society's Gold Medal to Dr. W. von Braun. *Left to right,* Gordon Thompson, Arthur Clarke, Wernher von Braun and Les Shepherd.

Dr. L. R. Shepherd *(right)* chats with Valentina Tereshkova, visiting London to receive the Society's Gold Medal. *Left* is the Soviet Ambassador.

K. W. Gatland *(left)* and Patrick Moore *(right)* chat to Mrs. Alla Massevich, who addressed the Society on the Soviet Space Science Programme.

2 March 1960 it submitted a Memorandum to the Prime Minister on the need for a U.K. Space Programme. The recommendations included :

(1) A project to develop the Blue Streak and Black Knight rockets to provide a satellite launching vehicle (a design study for such a vehicle was eventually undertaken at the Royal Aircraft Establishment though it never actually flew).

(2) A detailed feasibility study of Communications Satellites, including an examination of their military significance (Communication Satellites are now common place and in constant use).

(3) A research programme on hypersonic winged vehicles and their use for controlled re-entry into the atmosphere (two decades later, USA has a Space Shuttle programme).

(4) Research and development programmes on new propulsion systems.

As the Western European governments now established the European Study Group for Space Research (GEERS) the time seemed opportune for a closer grouping of the European aeronautical societies. It was decided to hold periodic European Symposia on Space Technology. The BIS organised the first of such meetings, held at the Federation of British Industries House in June 1961. Similar symposia have been held ever since, with the venue rotating from country to country.

The titles of the subjects chosen for the Society's own one or two-day symposia during the early sixties showed how widely these ranged over most aspects of astronautics: topics included Communications Satellites, Liquid Hydrogen as a Rocket Propellent, Rocket and Satellite Instrumentation, Space Navigation, Materials in Space Technology, Navigation and the Early Exploration of the Moon, Astronautics in the School Curriculum, Generation of Power and Space, Meteorology from Space, Advanced Propulsion, Aerospace Vehicles, Ground Support Equipment, the ELDO Launching Vehicle and the Engineering of Scientific Satellites. The papers presented and reports of the discussions appeared in the Society's *Journal.*

As part of its work in the field of education, the BIS organised a course on Rocket Motor Technology, intended for teachers. A Teachers Handbook of Astronautics plus two supporting books and materials were published and proved popular.

It had long been one of the Society's duties to signal its recognition of the achievements of distinguished workers in astronautics by making appropriate awards. A grade of Honorary Fellowship had already been established and adapted for this purpose soon after the Society reformed after the war. Now that space flight had really come about it was deemed appropriate to extend the range of awards to gold and bronze medals and to silver plaques. The first gold medals were awarded in 1961 to Yuri Gagarin (for the first manned flight in space) and to Wernher von Braun (for the development of the Pershing, Redstone, Jupiter and Saturn rockets at NASA's George C. Marshall Space Flight Center). The third was awarded in 1964 to Valentina V. Nikolaeva (née Tereshkova), the first woman to make an orbital flight. Both the Russian cosmonauts were able to come to London to receive their medals and many members attended the ceremonies.

After much discussion in Council and on the advice of the Society's solicitors, a new Constitution (or rather Memorandum and Articles of Association) was approved in 1965. In that year the Council also submitted another

NASA "Spacemobile"– operated by the Society for 3½ months in support of its Educational Programme.

Memorandum on Britain's part in Space to H.M. Government. The recommendations were more detailed than in the previous submission, and included:

(1) A request for the establishment of a single Western European Space Authority and for the United Kingdom government to support and participate in the work of the Authority. Such a body, the European Space Agency, came into being in 1970 as a result of the merging of the European Launcher Development Organisation (ELDO) and the European Space Research Organisation (ESRO).

(2) The development and construction in Western Europe of more efficient and more powerful launch vehicles, including those capable of reuse for the transport of payloads into orbit.

(3) A programme of space research to be undertaken with the then existing and suggested vehicles: atmospheric soundings, studies of the Earth's environment near interplanetary space, deep space (lunar and planetary studies).

(4) In the field of manned space flight, it was recommended that Western Europe should concentrate on the fundamental task of transporting men to and from orbit (that is perhaps the most dated aspect of the recommendations – if written today, the reference would be to "men and women").

About this time the decision was taken to suspend publication of the *Journal* temporarily in order to place *Spaceflight* on a monthly basis from January 1966. *Spaceflight* has continued to appear monthly ever since, except for occasional double numbers made necessary by staffing problems at holiday times.

In 1966 the Society received a Spacemobile on loan from NASA for several months. This was a very large van, fully equipped with a wide variety of models, films and other visual aid equipment. Lecturers from the Society toured Britain with the vehicle to carry out experiments and demonstrations at hundreds of schools; colleges, teachers training centres, factories and service establishments.

By 1968 the finances of the Society had improved and it became possible to recommence publishing the *Journal*, first quarterly and later bi-monthly. Professor G. V. Groves was appointed Editor. The new Constitution now enabled the Society to be registered as a Charity, which gave it several tax advantages. An equipment fund was launched, which allowed composing and ancillary equipment to be bought, with the result that great savings were made in typesetting *Spaceflight* (from 1972) and the *Journal* (from 1974) typed out and paged in the Society's Headquarters, although still printed externally. The *Journal*, meanwhile, became a bi-monthly in 1968 and a monthly in 1970, with its page size increased in 1977 and again in 1978. These changes provided a greatly improved service to members but meant that the work at the office multiplied by an even greater factor. More working room was urgently required, especially since the threat of demolition of the Society's offices (to make way for redevelopment of the surrounding area) was looming.

A search was made for alternative premises and an appeal for funds to make such a move possible was launched. Members and friends responded handsomely and eventually a suitable site was found. The building then standing was derelict and would have seemed anything but suitable to the casual observer. However, to a discerning eye it could be seen to have potentialities, and eventually it was purchased. Then began the long and tedious task of drawing up plans for its rebuilding, obtaining planning permission, modifying the plans to satisfy conditions imposed by the Lambeth Borough Council (part of the site was occupied by a listed building and required special treatment), the London Fire Services and others. Then builders had to be selected and contracts drawn up to the satisfaction of all parties including the solicitors. Eventually the actual rebuilding commenced, but, as unexpected difficulties were encountered, the plans had to be modified accordingly. During this period the Executive Secretary and his staff were placed under great pressure but, at the same time – managed to maintain and even expand the Society's publications (both *Spaceflight* and the *Journal* changed to a larger page size during this period and in 1979 *Spaceflight* was enlarged from a standard 40 pages to 48 pages).

In April 1974, the first of a series of special "red-cover" (Interstellar Studies) issues of the *Journal* was published. This was a subject in which the BIS had a long-standing interest. "Red-cover" issues have continued to appear at frequent intervals. A group of BIS members have also been working on a Starship study since 1972; this study was given the name "Project Daedalus" and its objective was to determine the feasibility of performing an Interstellar mission using only current, or immediately forseeable, science and technology. The work of the study group culminated in the publication by the Society of a very successful book "Project Daedalus" by A. Bond and A. R. Martin (1977).

Now the Society's new premises are available and besides providing more convenient offices for the administration of the Society's work, the preparation of publications, and the storage of records, they include for the first time, provision for our own Conference Room, space for the creation of a Library and for mounting exhibitions, and a reception area for members.

A new phase in the life of the BIS is beginning and we have every confidence that our Society will now go on to even greater achievements.

SPACE CENTRE IN VAUXHALL

By Eric Waine

Earlier this year the Headquarters of THE BRITISH INTERPLANETARY SOCIETY was moved into new buildings south of the Thames as positive proof of the outstanding success of our Development Programme begun in 1974. For this transformation in our affairs, much is owed to the generosity of Members and Friends at home and overseas who contributed to our Development Appeal. The site on which our new offices stand is part of an historic area of London which is now undergoing considerable development. In this article, Eric Waine looks back over more than 700 years.

Manor of South Lambeth

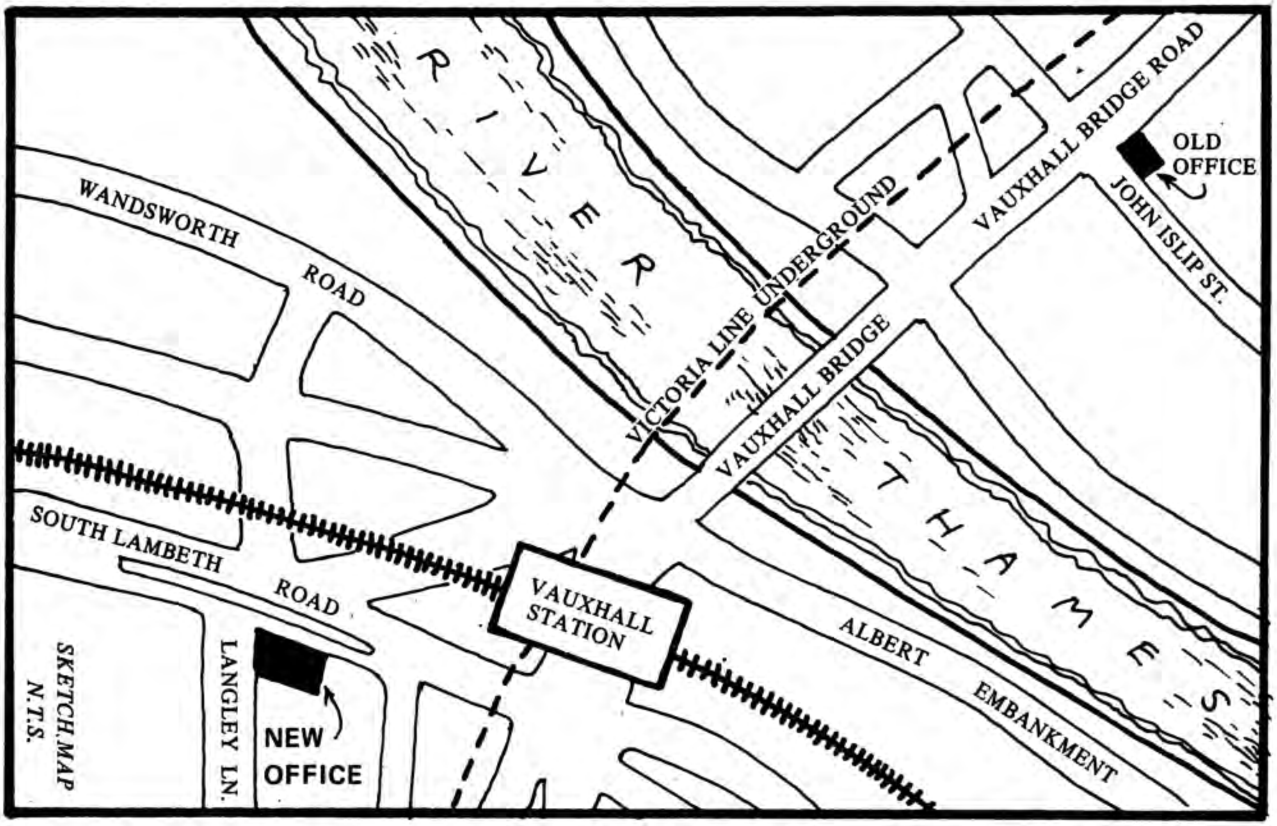
The ancient parish of Lambeth, although only a mile wide from east to west, was nearly six miles long from north to south and it extended from the River Thames opposite Temple Gardens to the wooded heights overlooking the great parish of Croydon. In Lambeth Parish in the 13th century a very sparsely populated area now known as Vauxhall was part of the manor of South Lambeth, owned by the de Redvess family. The names Fawkyshall and Fauxhall stemmed from Falkes de Breaute, the second husband of Margaret, widow of Baldwin de Redvess. An inquisition into the de Redvess estate in 1263 shows that the manor of South Lambeth included lands at Mitcham and Streatham but omitted reference to Vauxhall, although de Breaute's lands after his death had undoubtedly reverted to the de Redvess family. In 1293 the Manor of South Lambeth and la Sale Faukes passed, probably by trickery, into the hands of King Edward I. At that time the manor seems to have been split up into Vauxhall and Stockwell, each of which were granted manorial status. The name South Lambeth has survived only as an undefined area on either side of South Lambeth Road.

Manor of Vauxhall

In 1337, King Edward III granted the Manor of Vauxhall to the Black Prince who, a quarter of a century later, granted it to the Prior and Convent of Christ Church, Canterbury to maintain a chantry in the cathedral crypt. From this time, 1362, Vauxhall Manor encompassed Vauxhall, South Lambeth, Streatham and Mitcham. After the Dissolution of the Monasteries, 1529, the manor was transferred to the Dean and Chapter of Christ Church, Canterbury, but some of the land in Lambeth Marsh was granted to the Archbishop of Canterbury and absorbed into the demesne lands of the Manor of Lambeth. Demesne lands were those retained in the hands of the Lord of the Manor, as distinct from other parts of the manor sold or given to freeholders.

Until the 16th century, freeholders still owed allegiance and had to pay heriots of their best produce to their lord as a kind of rent. They had to plough the land twice a year and, once a year, provide oxen to carry the lord's hay. They also arranged two boon days on which all tenants attended for service to the lord and to carry the lord's hay. For most of these boons or unpaid services the tenants had rights to estovers of food and drink provided by the lord of the manor. An heir succeeding to a freehold had to pay a relief to the lord. Copyhold tenants held as proof of tenancy a copy of the court rolls prepared by their lord's steward. Inheritance was by Borough-English custom in which the youngest son inherited all or, if there were no son, the estate went to the youngest daughter. Heriot custom was payable to the lord

BIS HEADQUARTERS 1979, 27/29 South Lambeth Road, London, SW8 1SZ.



Location of our new HQ Building.

on the death or alienation of a tenant unless he died in battle.

Manorial accounts for the period include repairs to a barn which had mud walls and was thatched with reeds which were probably gathered from the local Thames marshes. The office of bedell for both the manor of Vauxhall and Walworth were usually held by the same man, often a land tenant. The Prior and Convent owned many scattered manors in South East England administered by laymen and visited by the Convent's officers only once or twice a year. With the Enclosure of common land, which was well advanced in the 16th century, closes were leased to provide rents more acceptable to absentee landlords than were the old feudal services. Court rolls for 1651-2 and 1653-9 show John Adrian and Henry Hampson respectively as Lords of the Manor of Vauxhall.

A map of the manor drawn by Thomas Hill in 1681 shows an area of freehold land through which South Lambeth Road and Wandsworth Road converged northwards towards Cox's Bridge and Kennington Lane. The bridge, sometimes called Vauxhall Bridge but known earlier as Cokkesbrugge orCockesbridge, spanned one of many common open sewers giving into the Thames; this waterway was called Vauxhall Creek. The map also shows further south a second sewer to the Thames and known as Battersea Ditch. These sewers were in fact two arms of the River Effra and, with the south bank of the Thames linking them, they formed boundaries of the manor. Tributaries of the Effra rose in Norwood, combined and the stream sometimes called the Washway flowed to Kennington. Just west of Kennington, the Effra divided into Vauxhall Creek and Battersea Ditch. There was a turnpike at Cox's Bridge with a wharf nearby and early in the 17th century a dispute arose over maintenance of the bridge. Because of "enundacion and outrage of waters" it had become "prostrate and throwne downe" and fallen stones hindered the flow. The Commissioner of Sewers adjudged the responsibility for repairs to be with the Crown, but a surveyor appointed could not find the land in question, even by "dilligent enquiery" and he denied Crown responsibility. Following an Act of Parliament of 1717, branch roads like the Vauxhall-Brixton road (now South Lambeth Road and Stockwell Road) were made the responsibility of the Turnpike Trustees who, in 1786, became the Trustees for Surrey New Roads. Apart from these trustees, public administration made little impact on the manor until the latter half of the 19th century.

Vauxhall Bridge

Before the 19th century, there were few roads and buildings in Vauxhall; in 1801, the population of the entire Lambeth Parish was only 27,985. The different types of land tenure which had persisted for centuries, small fields, etc. made it difficult to obtain contiguous land for worthwhile development and hindered the building of new roads. Being close to London, the area was given to dairies and market gardens which were very profitable. A map of 1799 shows for the first time a line of a dozen houses, known as Vauxhall Place, set back from the eastern side of South Lambeth Road at its northern end and, seemingly, they were adjoined on three sides by fields, allotments, etc. At the beginning of the 19th century there was still no bridge over the Thames between the bridges at Westminster and Battersea; most of the demesne lands of Vauxhall manor were sold but the copyhold lands remained as part of the capitular estate of Christ Church, Canterbury until vested in the Ecclesiastical Commissioners in 1862.

London was expanding on the north bank of the Thames, the demand for another bridge increased and where better to build it than to the point on the south bank where Kennington Lane, Nine Elms Lane, South Lambeth Road

and Wandsworth Road converged? An Act of Parliament of 1809 established the Vauxhall Bridge Company to build the bridge and approach roads and on 9th May 1811 Lord Dundas laid the foundation stone for the Prince Regent of what was intended to be known as The Regent's Bridge. After some changes in designs and contracts, the toll bridge was opened to pedestrians and vehicles in 1816 and it quickly became known by the present name of Vauxhall Bridge. Its nine arches, each of 78 feet span, were only 36 feet wide but it helped to accelerate the expansion of London on the south bank. Roads were the principal factor determining the course of building development in those days. The turnpike road system in the area was completed in 1818 with the building of Camberwell New Road, Harleyford Street and Harleyford Road as a new approach road to the bridge.

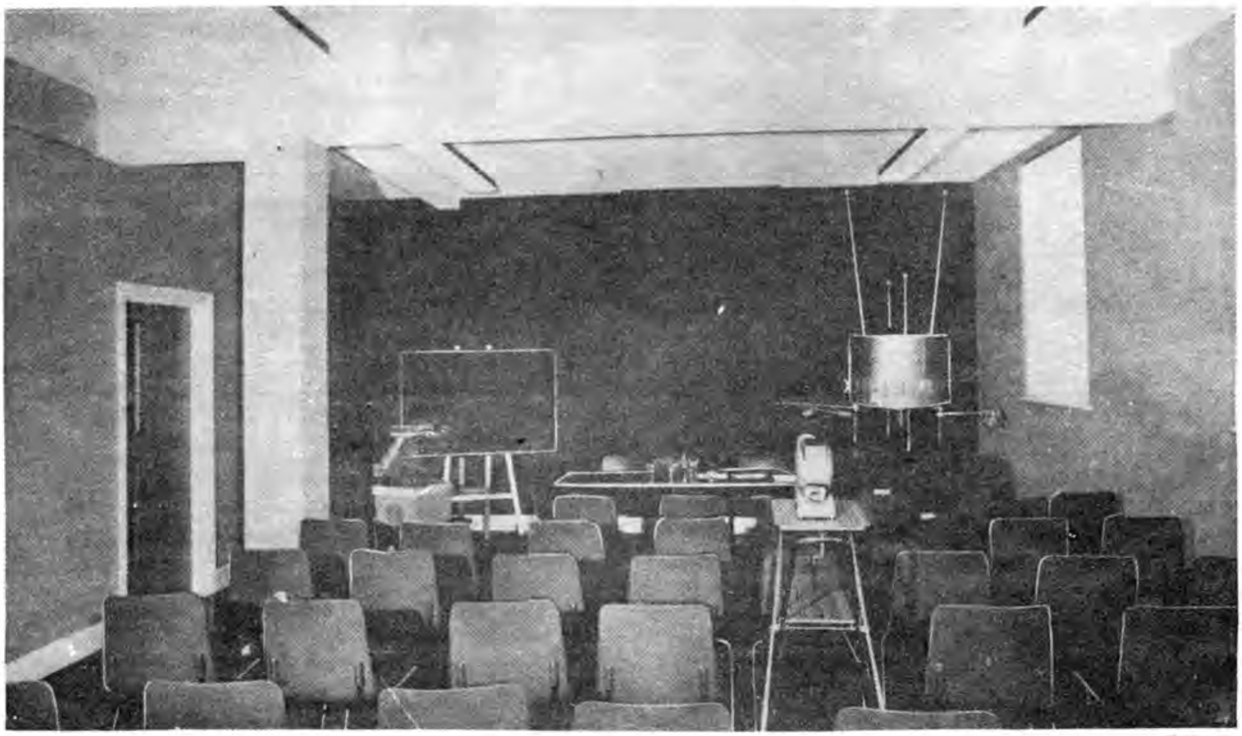
Vauxhall Place

It is likely that there was some rebuilding in Vauxhall Place in this period because 13 dwellings were recorded in the 1841 census. As we shall see later, nos. 12 and 13 at the southern end of the terrace are of particular interest. No. 12 was then occupied by colonial broker William Hewitt, his wife Anne, sons Edward and Thomas, daughter Emily and servant Ann Dove; no. 13 was the home of Samuel Wolf of independent means, Eliza Hayes, Isobel and Laura Thomas and two servants Sarah Gray and Jane Hodgson. Houses tended to be built in long terraces and there was little public supervision of building development until 1844 when the Office of Metropolitan Buildings was established. In 1848 an exciting new development occurred. The London and South Western Railway was opened and steam trains ran over high arches, for all to see, parallel to and just across the road from Vauxhall Place. It was a miracle of the scientific age and it had a profound impact on housing development. Houses no longer needed to be near main roads nor to have stables and a coach-house attached. Less-prosperous folk began moving to the suburbs and to travel to work by rail. The 1851 census tells us that no. 12 was occupied by Richard Grant, a Solicitor managing a club, his wife Sarah, two sons, two daughters, a maidservant and three visitors, whilst at no. 13 were Samuel Hayes, retired from East India House, and his wife Eliza. I wonder if these good people spared a thought for the convicts across the river sentenced to transportation from Millbank Prison, for until 1867 they were often to be seen embarking from the river steps just downstream of Vauxhall Bridge to start their long journey to Australia.

Public control of building development was taken over by the Metropolitan Board of Works (MBW) in 1855 which was probably just as well because in 1877 the Metropolis Toll Bridges Act came into force. Under this Act the MBW bought the bridges from the companies and abolished the tolls. The free opening of Vauxhall Bridge on 24th May 1879 was performed by the Prince and Princess of Wales (later King Edward VII and Queen Alexandra) and this gave impetus to the traffic flow, to the influx of people and to the rapid growth of housing in Vauxhall. Meanwhile, a directory of 1868 records the names of the last residents of 12 and 13 Vauxhall Place as Mrs. Barker and James Desgranges respectively. They were the last because by this time building development in South Lambeth Road was so extensive that rationalisation of the house numbering was imperative.

27 and 29 South Lambeth Road

On 29 May 1868, the MBW renumbered the buildings and 12 & 13 Vauxhall Place became 27 & 29 South Lambeth Road. No. 27 was occupied by John Godfrey but its owner was a Mr. Young who lived in N.E. London; James Desgranges still lived at no. 29. The Valuation (Metropolis) Act of 1869 introduced a property valuation system on which properties were taxed annually and in 1870, with the same occupiers, each property was accorded a rateable value of £28 per annum. In 1875, the occupiers of nos. 27 & 29 were Mrs. Barker and Robert Jacques respectively (the owner of no. 29 was T. H. Howell). No. 27 still had a rateable value of £28 per annum but that of no. 29 had risen to £39 per annum suggesting that the classification had changed to business



GOLOVINE CONFERENCE ROOM seats more than 50 people and is fully equipped for slide and film projection.

The one-quarter scale model of Ariel 4 supplied on loan by British Aerospace.

premises. This tends to be confirmed by an 1881 directory which states that Joseph William Thompson, a coke contractor, was based at no. 29, whilst Mrs. Barker still resided at no. 27.

The gradients of Vauxhall Bridge became inadequate for the increasing traffic and in 1898 the London County Council (LCC) erected a temporary bridge and began demolishing the original structure. By this time the development of Vauxhall was virtually complete and horsedrawn trams and omnibuses were travelling in great numbers along most of its main roads. In 1901, the population of the Metropolitan Borough of Lambeth (whose boundaries differed little from the Parish) had risen to 301,895 – a ten-fold increase in 100 years. The LCC looked ahead and designed the present Vauxhall Bridge which was opened by the LCC Chairman Evan Spicer on 26th May 1906. From the centre, its five arches span 149 feet 7 inches, 144 feet 4¾ inches and 130 feet 5¾ inches respectively and are 80 feet wide. Improved gradients and doubled width speeded and increased the London-Vauxhall traffic.

Original painting presented by Chesley Bonestell being prepared ready for display at our new HQ building.

Since then, there have been other occupiers of nos. 27 & 29 as directories show:

Date	*No. 27*	*No. 29*
1909	Walter Beavis	Walter Cousin, Sign-writer
1923	Daltons Weekly House and Apartment Advertiser and Boarding House Guide	John Hill, carman
1931-1967	Daltons Weekly	Daltons Weekly
1972	South London Plastics Limited	–

The rest of the terrace, nos. 5/25, have long since disappeared probably as a result of bombing during the 1939-45 war. Nos. 27 & 29, unoccupied and vandalised in recent years, were purchased by the British Interplanetary Society in 1978 and contractors have since been renovating them. No. 29 is a listed Victorian building which imposes certain preservation responsibilities on its owners; no. 27 is of more recent construction. The exact ages of these buildings are not known but both have been made very presentable and have given an uplift to the area. However, it is depressing to record that even as the contractors approached the end of their work, some of the newly-erected railings, replicas of the Victorian era, were broken by vandals. Thus, the struggle to maintain our hard-won office may be said to have started already.

MEMBERS' ADVERTISEMENTS

Special Rate to members advertising the sale of personal property: 50p per line, minimum £2.50 ($5.00).

NOTICE. The Society does not accept responsibility for the accuracy of statements or quality of goods advertised.

WANTED: Complete boxed set: Photographic Lunar Atlas (c. 1960) by Kuiper with Arthur, Moore, Tapscott and Whitaker (printed by University of Chicago Press). Please submit list of contents and quote best delivered price to: Harold S Bates RR#2 Box 170, Hudson, New York 12534, USA.

SOCIETY T-SHIRTS

The range of Society T-shirts has been extended by adding an *EXTRA LARGE* size (42"-44") to the three standard sizes, i.e. *SMALL, MEDIUM* and *LARGE*.

The new T-shirt is most attractive: it is white with the Society's emblem printed in dark blue on the front.

The price per T-shirt, whatever the size, is £2.50 ($6.00) post free.

Orders and remittances to the Society at 27/29 South Lambeth Road, London SW8 1SZ.

DELTA DIGEST

By Andrew Wilson

Introduction

On 29 April 1959, the newly formed NASA signed its first launch vehicle development contract. It required Douglas Aircraft Company to produce Delta, a satellite launch vehicle based on the Thor IRBM, which was intended to be used as a stop-gap launcher during the 1960-61 period while larger vehicles were being flight qualified. As it turned out, the Delta became one of the most used launch vehicles but it will be flown at a much reduced rate after the Shuttle is introduced.

The following sections present brief details on each of the Delta variants, with a complete launch list included at the end.

One of the most confusing aspects of the Delta is the nomenclature adopted. Thus a particular type could be called Delta E, DSV-3E or TAID (Thrust Augmented Improved Delta). The latter version has been dropped altogether in this work. The Delta number given in the lists is not the manufacturer's number but merely the position in which a particular rocket was launched. The Delta terminology adopted today – the four digit numbers – is much easier to follow and is explained fully in the sections.

For convenience, a separate list of failures is included while the failures in the main list are indicated by '*'.

A comprehensive description of the Thor and early Delta is given in Ref. 1.

Delta (DM-19)

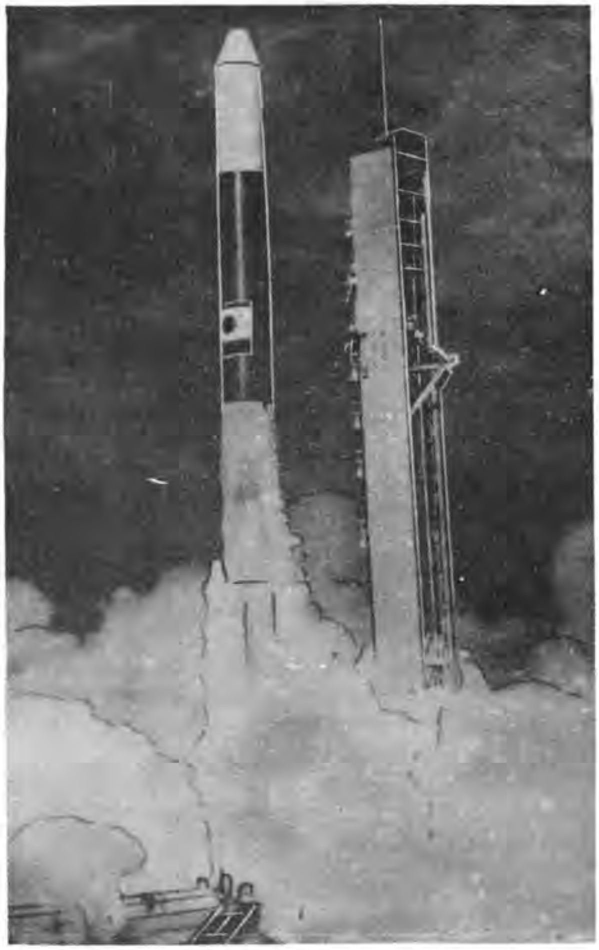
Capabilities:	100 lb to synchronous transfer orbit (ETR) 600 lb to 200 nm orbit (ETR).
Stage 1:	a modified DM-19 Thor powered by an MB-3 Block I engine (LR 79 NA-9), rated at 150,000 lbf.
Stage 2:	33 in diameter and powered by an AJ-10-142 engine.
Stage 3:	X-248 A7 solid fuel motor.
Guidance:	BTL-300 radio inertial.
Comments:	the original Delta version was used in the first 12 launches. Launch weights were: Delta 7, 8, 9, 10, 11 – 112,000 lb. Delta 12 113,000 lb.

Delta A (DSV-3A)

Capabilities:	150 lb to synchronous transfer orbit (ETR). 700 lb to 200 nm orbit (ETR).
Stage 1:	a modified DM-21 Thor powered by an MB-3 Block II engine (LR 79 NA-11) at 165,000 or 175,000 lbf. Two verniers added 1000 lbf each further. length – 59 ft 8 in. maximum diameter – 8 ft. burn time – 146s.
Stage 2:	33 in diameter, powered by an AJ-10-118 engine, with retro capability.
Stage 3:	X-248 A5D solid fuel motor.
Guidance:	BTL-300 radio inertial.
Comments:	Delta A had two launches – Explorer 14 (Delta No. 13) Explorer 15 (Delta No. 14).

Delta B (DSV-3B)

Capabilities:	150 lb to synchronous transfer orbit (ETR). 830 lb to 200 nm orbit (ETR).
Stage 1:	see Delta A
Stage 2:	the stage was lengthened to 248 in to increase the burn time of the AJ-10-118D to 170s. thrust – 7575 lbf. loaded weight – 5936 lb. propellents – IRFNA/UDMH. maximum diameter – 32 in.
Stage 3:	X-248 A5DM solid fuel motor. length – 5 ft. thrust – 2760 lbf burn time – 42s. loaded weight – 528 lb. maximum diameter – 18 in.
Guidance:	BTL 600 radio inertial.
Comments:	Delta B had 9 launches, numbers 15-20 and 22-24. Number 24, carrying Beacon Explorer A failed to orbit because of in-



Experimental Japanese communications satellite designated BSE is launched from the Kennedy Space Center on 7 April 1978 aboard Delta 140.

National Aeronautics and Space Administration

sufficient third stage thrust; only 22s of the planned burn took place. This failure was the first since the first launch in 1960.

Delta C and C1 (DSV-3C, 3C1)

Capabilities: 180 lb to synchronous transfer orbit (ETR).
900 lb to 200 nm orbit (ETR).

Stage 1: see Delta A.

Stage 2: see Delta B.

Stage 3: X-258 solid fuel motor with a larger payload fairing (C1).
X-248 for variant C.

Guidance: BTL 600 radio inertial.

Comments: Delta C had 10 launches, numbers 21, 26-29, 31-33, 36 and 46.
Delta C1 had three launches, numbers 38, 53 and 64.
Delta 33 failed to orbit OSO C because of premature third stage ignition.
The launch of Delta 29 was delayed following an accident while the OSO satellite was being mated to the third stage for spin tests. The motor ignited, injuring 11 people, 3 of them fatally. It was found the X-248 had been ignited by static electricity, a fault inherent in the design.

Delta D (DSV-3D)

Capabilities: 230 lb to synchronous transfer orbit (ETR).
1,270 lb to 200 nm orbit (ETR).

Stage 1: Delta D introduced the MB-3 Block III (LR79 NA-13) engine, at a thrust of 170,000 lbf. Boosters were used for the first time, in the form of three Castor 1s (TX33 52).

Stage 2: see Delta B.

Stage 3: see Delta C1.

Guidance: see Delta C.

Comments: Delta D was employed in 2 launches, numbers 25 and 30, the latter orbiting the Early Bird satellite.

Delta E and E1 (DSV-3E, 3E1)

On 11 June, 1964 NASA made public the details of modifying the Delta second stage, increasing its diameter from 32 to 54 in and its burn time from 116 to 400s. The initial contract called for eight vehicles to be modified at a cost of $8m. Fifteen and ten more were ordered in 1965 and 1968, respectively.

Capabilities: 450 lb to synchronous transfer orbit (ETR).
1,620 lb to 200 nm orbit (ETR).
1,220 lb to 200 nm orbit (WTR).

Stage 1: see Delta D. Three Castor 2's sometimes replaced Castor 1's as boosters.

Stage 2: the second stage is now 54.7 in in diameter and powered by an AJ-10-118E engine, with restart capability.

Stage 3: FW-4 solid fuel motor (for Delta E1)
X-258 solid fuel motor (for Delta E)

FW-4 characteristics: weight – 660 lb.
thrust – 5,450 lbf.
height – 62 in.
diameter – 20 in.
burn time – 31s.

Guidance: see Delta C.

Comments: Delta E had six launches, numbers 34-37, 41, 45 and 48.
Delta E1 had 17 launches, numbers 39, 40, 42, 44, 47, 49, 50, 52, 54, 55, 56, 60, 61, 65, 67, 69, 84.

see Deltas G and J.

The E variant was the first Delta to be launched from WTR and Delta 61 was the first NASA satellite launch vehicle sold to a foreign country.

Delta G (DSV-3G)

Delta G was a two stage version of the E and was used in only two launches, numbers 43 and 51, launching Biosatellites 1 and 2, respectively.

Delta J (DSV-3J)

Delta J was a Delta E but with the FW-4 third stage motor replaced by a TE 364-3 solid fuel motor. It was used once only, to launch Explorer 38 with Delta 57.

Delta L (DSV-3L)

Stage 1: the L carried the Long Tank Thor first stage (introduced by the N, a variant of the L) which did not taper off towards the forward end. Stage length was 70.3 ft. Three Castor 2's were used for boost.

Stage 2: see Delta E.

Stage 3: FW-4D solid fuel motor.

height – 5 ft.
weight – 14,000 lb.
thrust – 7,400 lbf (s.l.).
diameter – 5.8 ft.

Guidance: see Delta C.

Comments: Delta L was used three times as such but it was more employed in the M and N versions.
Of the three L's launched – 73,82 and 87 – number 73 failed to orbit because of vibration causing an oil leak in the hydraulic system.

Delta M (DSV-3M)

A variant of the L but carrying a TE 364-4 as third stage.

See Delta 2000 series for third stage details.

Delta M was used in 11 launches, numbers 59, 63, 66, 68, 71, 74, 75, 77-80.

Delta 59 failed to orbit Intelsat 3A because of a pitch rate system malfunction, forcing range safety destruct. The probable cause was a loose wire in the first stage guidance system.

Delta 71, carrying Intelsat 3E, failed to orbit either because of third stage nozzle failure or motor casing rupture. This failure was closely followed by that of Delta 73 (Delta L), causing all Delta missions to be grounded while investigations were carried out.

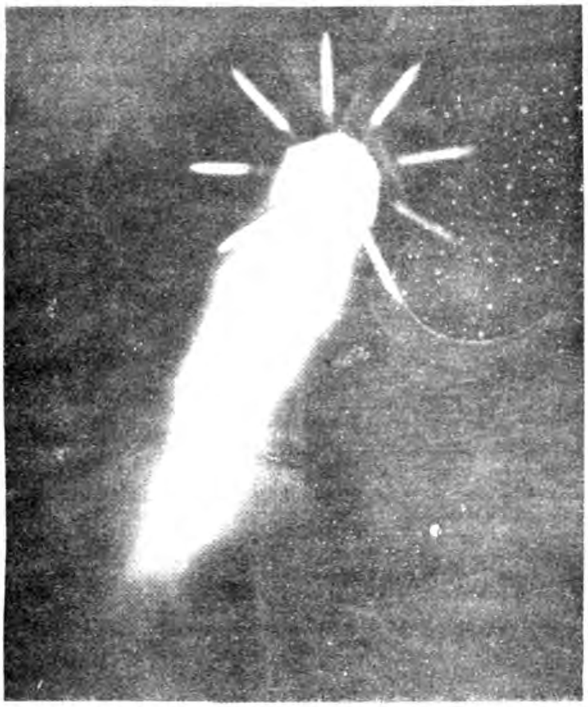
Delta N (DSV-3N)

A variant of the Delta L but with no third stage. Used in numbers 58, 62, 70, 72, 85 and 88.

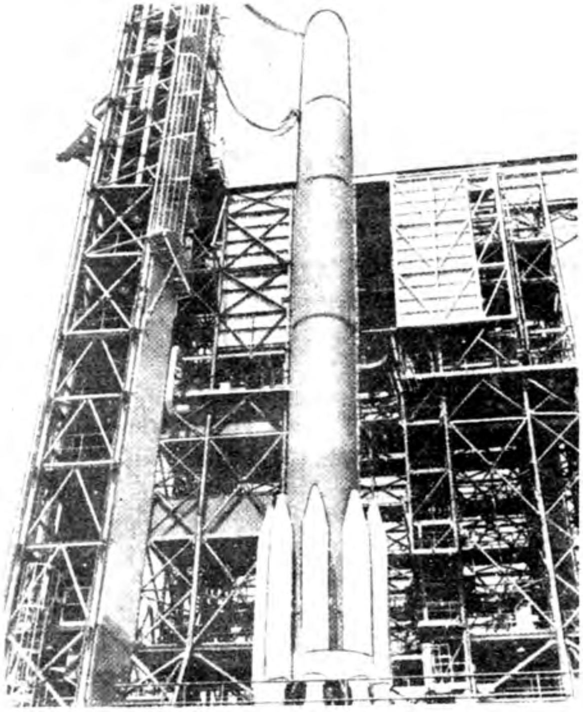
See also Delta N6.

Delta M6 and N6

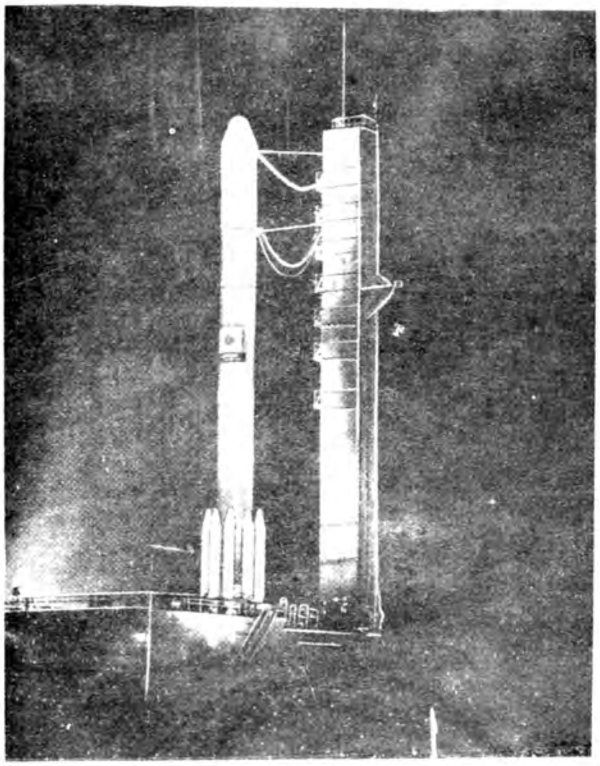
Instead of the usual three boosters of the M and N



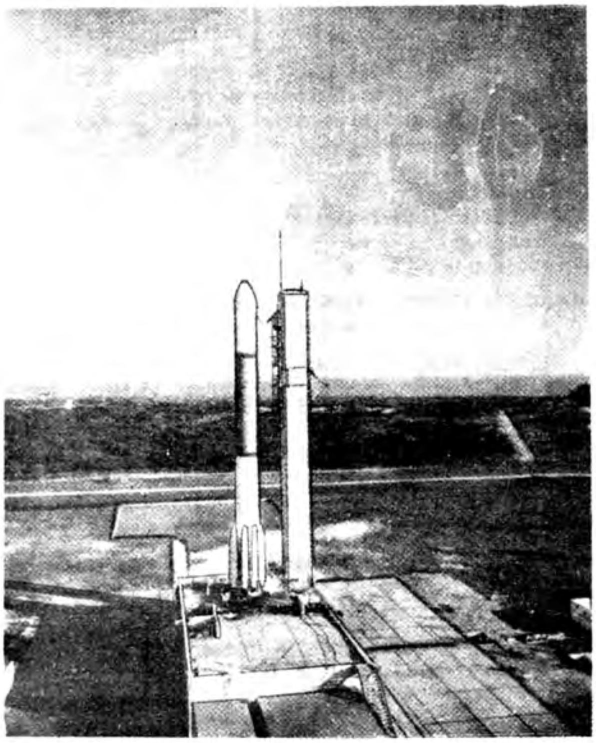
KENNEDY SPACE CENTER. The nine solid rocket motors used to augment the thrust of Delta 116 are shown being jettisoned in this photograph taken by a tracking camera at Cocoa Beach during the launch of Geostationary Operational Environmental Satellite (GOES 1).



NATO 3A, first in a new series of military communications satellites to serve the North Atlantic Treaty Organisation, ready for launching by Delta 122 on Complex 17 at Cape Canaveral Air Force Station.



Delta 132 stands poised at Complex 17 for the launch of Geostationary Meteorological Satellite, the Japanese Government's first weather satellite placed into a synchronous orbit above the Pacific Ocean due south of Tokyo.



Delta 148 at Launch Complex 17B ready to launch SCATHA, an Air Force research satellite designed to study the problem of static charging on high altitude satellites.

All photographs National Aeronautics and Space Administration.

launchers, the M6 and N6 (commonly termed 'Super Six') carried six. Three ignited at launch and three at T+31s, jettisoning in two groups at T+90s and T+95s. Used in numbers 76, 81, 83 and 86. Number 86 suffered a second stage malfunction.

Delta 100 Series

From 1972, the designation system used for Delta launch vehicles was changed from the old letter type (e.g., Delta E) to a more logical number type, the 100 series using three digits to indicate the following:

1st digit – number of strap on boosters.

2nd digit – indicated AJ-10-118F second stage. Always 'O'.

3rd digit – type of third stage, 0 = no third stage. 4 = TE 364-4.

Stage 1: see Delta L. The first stage carried the Universal Boattail (UBT) to allow 3, 6 or 9 boosters to be used.

Stage 2: AJ-10-118F with N_2O_4 and Aerozine 50 as propellants.

thrust – 9,500 lbf (vac).
burn time – 335s.

Stage 3: TE 364-4 solid fuel motor. See Delta 2000 series.

Guidance: see Delta 2000 series.

Comments: the whole series was used five times only.

Delta 89 launched	Erts 1	Delta 900
Delta 91	Noaa 2	Delta 300
Delta 93	Nimbus 5	Delta 900
Delta 96	Itos E	Delta 300
Delta 98	Noaa 3	Delta 300

Although available, no third stage or six strap-ons were ever carried. The failure of Itos E to orbit was caused by second stage malfunction.

Delta 1000 Series

The 1000 series introduced the 'Straight Eight' Delta, so called because of a constant 8 ft diameter. The four digits were used to indicate the following:

1st digit – always '1' in this series, showing first stage was an Extended Long Tank Thor (ELT).

2nd digit – number of strap-ons.

3rd digit – type of second stage, 0 = vehicle not of constant diameter. 1 = vehicle a Straight Eight. In 2000 series this meant second stage was TR 201.

4th digit – type of third stage, 0 = no third stage. 3 = TE 364-3 motor. 4 = TE 364-4 motor.

Capabilities: 1,500 lb to synchronous transfer orbit, ETR (1904).
1,400 lb to synchronous transfer orbit, ETR (1914).
4,050 lb to 200 nm orbit ETR (1900).
2, 960 lb to 200 nm orbit, WTR (1900).

Stage 1: Used the Extended Long Tank (ELT) Thor, with a length of 70 ft. The engine is still the MB-3 Block III. The first stage could carry 3, 6 or 9 boosters (Castor 2).

Stage 2: AJ-10-118F engine, see Delta 100 series.

Stage 3: TE 364-3, TE 364-4 or no third stage. See 2000 series.

Guidance: see 2000 series.

Comments: used in six launches.

Delta 90 launched	Explorer 47	Delta 1604.
Delta 92	Anik 1	Delta 1914.
Delta 94	Anik 2	Delta 1914.
Delta 95	Explorer 49	Delta 1913.
Delta 97	Explorer 50	Delta 1600.
Delta 99	Explorer 51	Delta 1900.

Delta 2000 Series

The 2000 series has been used in six versions to date: 2310, 2313, 2910, 2913 and 2914.

The terminology is as follows:

1st digit – always '2' in this series, indicating use of RS 27 engine.

2nd digit – number of boosters used.

3rd digit – '1', indicating the TR 201 as the second stage.

4th digit – type of third stage, 0 = no third stage. 3 = TE 364-3 motor. 4 = TE 364-4 motor.

Stage 1: The first stage is powered by a single Rocketdyne RS 27 engine, modified from the H1 of the Saturn programme. An initial thirty-test verification programme was completed in October 1972 on the first engine. The first production delivery was made in January 1973. The contract called for 30 units (one main and two vernier engines) to be delivered up to March 1975.

RS-27 data

thrust – 205,000 lbf (RS2701A).
weight – 2,260 lb.
specific impulse – 262s.
rated duration – 242s.
flowrate – LOX 541 lb/s.
RP1 240 lb/s.
dimensions – 142.3 in long.
66.8 in envelope diameter.

SRMs 3, 4, 6 or 9 TX 354-5 can be used for boost. With the 9 configuration, 6 SRMs ignite at liftoff and 3 after the first six burn out.

Castor 2 data

length – 247 in.
diameter – 31 in.
dry weight – 1,630 lb.
propellant weight – 8,220 lb.
thrust at liftoff is 33,000 lbf, increasing to 62,000 lbf at maximum, giving an average thrust of 54,000 lbf for 38s.

Interstage. Stretches from the top of the first stage and covers part of the second stage.

length – 186 in.
weight – 980 lb.
diameter – 96 in.

Mini-Skirt. This sits on top of the interstage, carrying main umbilical connectors and antennae. It is only 11 in high.

Stage 2: The second stage, suspended from the mini-skirt inside the interstage adapter and spacecraft, is a modified version of the TRW Lunar Module Descent Engine (LMDE) TR 201 capable of multiple starts. A cold N_2 gas system provides roll control in powered flight and full control during the coast phase.

thrust – 9,850 lbf.
length – 232 in.
burn time – 335s.
diameter – 54.7 in.
propellants – N_2O_4 and Aerozine 50.
dry weight – 1,849 lb.
propellant weight – 10,120 lb.

Stage 3: Two third stages are available, both spin stabilised:

TE 364-3	*TE 364-4*
length – 52 in.	length – 72 in.
diameter – 37.5 in.	diameter – 38 in
average thrust – 10,000 lbf.	average thrust – 15,000 lbf.
propellant weight – 1,440 lb.	propellant weight – 2,300 lb.

The 364-3 was originally the main Surveyor retromotor, modified for Delta use by increasing the propellant and re-designing the attach structure.

Guidance: The Delta Inertial Guidance System (DIGS) is a strap-down all-inertial unit consisting of an inertial measuring unit and guidance computer, utilising the Apollo LM Abort Sensor Package and the computer developed for the Centaur. Modification of Delta began in December 1969 and the first DIGS flew in the 100 series.

Spacecraft fairing: An all-metal, bishell protects the spacecraft while in the atmosphere and is jettisoned after second stage ignition.

Comments: Of all the 2000 series, the 2914 version is by far the most flown, while the 2410 has flown once only to date.

Following a steering fault in the second stage of the 2313 carrying Skynet 2A, the satellite did not attain the intended synchronous orbit and radio contact was lost. Contact was re-established on 24 June but an orbit manoeuvre was unsuccessful and the satellite decayed during the following day.

As an illustration of the launch events of a Delta flight, the following are scheduled events of the Delta 2914 during the Palapa 1 launch on 8 July 1976:

Ignition	T+0s
Six solids burnout	T+38s
Three solids ignite	T+39s
Three solids burnout	T+77s
Nine solids jettison	T+87s
First stage cutoff	T+228s
First/second stage sep	T+236s
Second stage ignition	T+241s
Fairing jettison	T+275s
Second stage cutoff	T+535s
Second/third stage sep	T+1354s
Third stage ignition	T+1395s
Third stage burnout	T+1439s
Third stage/sat sep	T+1512s

Delta 3914

The first envisaged use of the 3914 was that of launching the experimental aviation comsat, Aerosat, in late 1977 or early 1978. Aerosat was originally to have carried L-band equipment for voice exchange but pressure from within the U.S. forced inclusion of VHF channels to allow the system users to decide for themselves which was the superior mode. However, this change made Aerosat too heavy for launch by 2914 and an alternative had to be found in the form of the 3914, a development which NASA resisted because it meant introducing a new Delta form only a few years before the Shuttle was to come into operation. NASA was afraid the 3914 would affect Shuttle planning, possibly taking away future international payloads, so RCA Globecom (Aerosat contractor) and McDonnell Douglas (Delta contractor) took on the costs of development.

A second payload was to have been the domestic comsat, Satcom, too heavy for the 2914 to put into a synchronous orbit (the 2914 can handle 1,550 lb for this orbit) and not worth using the relatively expensive Atlas-Centaur. Ready before Aerosat, Satcom 1 was launched by Delta number 118 and Satcom 2 by number 121 in December 1975 and March 1976, respectively.

The difference between the 2914 and 3914 versions is in the solid boosters – the 3914 incorporates nine TX 526 (Castor 4) SRMs, at 85,000 lbf thrust each, giving a 29% payload increase over the 2914. Five of the boosters ignite on the pad, with the remaining four burning at around T+60s.

The first 3914 failure occurred during the launch of the European OTS when observers saw the first stage begin to break up after the number one Castor 4 showed evidence of rupturing. Total launch and Delta costs were $16.3 million with the Delta costing $6.98 million alone but ESA had insured OTS, the Delta and associated services for $29.1 million.

Delta Launch Failures

Failures in this list are defined as those in which the payload did not achieve orbit.

No.	Payload	Type	Comments
1	Echo A-10	DM-19	second stage attitude control malfunction.
24	S-66	DSV-3B	insufficient third stage thrust.
33	OSO-C	DSV-3C	premature third stage ignition.
59	Intelsat 3A	DSV-3M	pitch rate system fault, first stage shook apart.
73	Pioneer E	DSV-3L	first stage hydraulic failure.
86	ITOS-B	DSV-3N6	second stage attitude control malfunction.
96	ITOS-E	300	second stage attitude control malfunction.
134	OTS	3914	rupture of Castor 2, damaging first stage.

Acknowledgements

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REFERENCE

1. K. W. Gatland, *Spacecraft and Boosters*, Iliffe Books Ltd., 1964.

Metric Conversions

Multiply	By	To obtain
Inches	2.54	centimetres.
Feet	0.3048	metres.
Statute miles	1.609	kilometres.
Nautical miles	1.852	kilometres.
Pounds	0.4536	kilograms.
Pounds	4.448	newtons.

Delta launch history

	Payload	Date	Type
1*	Echo A-10	13 May 60	DM-19
2	Echo 1	12 Aug 60	DM-19
3	Tiros 2	23 Nov 60	DM-19
4	Explorer 10	25 Mar 61	DM-19
5	Tiros 3	12 Jly 61	DM-19
6	Explorer 12	15 Aug 61	DM-19
7	Tiros 4	8 Feb 62	DM-19
8	OSO 1	7 Mar 62	DM-19
9	Ariel 1	26 Apr 62	DM-19
10	Tiros 5	19 Jun 62	DM-19
11	Telstar 1	10 Jly 62	DM-19
12	Tiros 6	18 Spt 62	DM-19
13	Explorer 14	2 Oct 62	DSV-3A
14	Explorer 15	27 Oct 62	DSV-3A
15	Relay 1	13 Dec 62	DSV-3B
16	Syncom 1	14 Feb 63	DSV-3B
17	Explorer 17	2 Apr 63	DSV-3B
18	Telstar 2	7 May 63	DSV-3B
19	Tiros 7	19 Jun 63	DSV-3B
20	Syncom 2	26 Jly 63	DSV-3B
21	Explorer 18	26 Nov 63	DSV-3C
22	Tiros 8	21 Dec 63	DSV-3B
23	Relay 2	21 Jan 64	DSV-3B
24*	S-66	19 Mar 64	DSV-3B
25	Syncom 3	19 Aug 64	DSV-3D
26	Explorer 21	3 Oct 64	DSV-3C
27	Explorer 26	21 Dec 64	DSV-3C
28	Tiros 9	22 Jan 65	DSV-3C
29	OSO 2	3 Feb 65	DSV-3C
30	Early Bird	6 Apr 65	DSV-3D
31	Explorer 28	29 May 65	DSV-3C
32	Tiros 10	1 Jly 65	DSV-3C
33*	OSO-C	25 Aug 65	DSV-3C
34	Explorer 29	6 Nov 65	DSV-3E
35	Pioneer 6	16 Dec 65	DSV-3E
36	Essa 1	3 Feb 66	DSV-3C
37	Essa 2	28 Feb 66	DSV-3E
38	Explorer 32	25 May 66	DSV-3C1
39	Explorer 33	1 Jly 66	DSV-3E1
40	Pioneer 7	17 Aug 66	DSV-3E1
41	Essa 3	2 Oct 66	DSV-3E
42	Intelsat 2A	26 Oct 66	DSV-3E1
43	Bios 1	14 Dec 66	DSV-3G
44	Intelsat 2B	11 Jan 67	DSV-3E1
45	Essa 4	26 Jan 67	DSV-3E
46	OSO 3	8 Mar 67	DSV-3C
47	Intelsat 2C	22 Mar 67	DSV-3E1
48	Essa 5	20 Apr 67	DSV-3E
49	Explorer 34	24 May 67	DSV-3E1
50	Explorer 35	19 Jly 67	DSV-3E1
51	Bios 2	7 Spt 67	DSV-3E1
52	Intelsat 2D	27 Spt 67	DSV-3G
53	OSO 4	18 Oct 67	DSV-3E1
54	Essa 6	10 Nov 67	DSV-3C1
55	Pioneer 8	13 Dec 67	DSV-3E1
56	Explorer 36	11 Jan 68	DSV-3E1
57	Explorer 38	4 Jly 68	DSV-3J
58	Essa 7	16 Aug 68	DSV-3N
59*	Intelsat 3A	18 Spt 68	DSV-3M
60	Pioneer 9	8 Nov 68	DSV-3E1
61	HEOS 1	5 Dec 68	DSV-3E1
62	Essa 8	15 Dec 68	DSV-3N
63	Intelsat 3C	18 Dec 68	DSV-3M
64	OSO 5	22 Jan 69	DSV-3C1
65	Isis 1	30 Jan 69	DSV-3E1
66	Intelsat 3B	5 Feb 69	DSV-3M
67	Essa 9	26 Feb 69	DSV-3E1
68	Intelsat 3D	21 May 69	DSV-3M
69	Explorer 41	21 Jun 69	DSV-3E1
70	Bios 3	28 Jun 69	DSV-3N
71	Intelsat 3E	25 Jly 69	DSV-3M
72	OSO 6	9 Aug 69	DSV-3N
73*	Pioneer E	27 Aug 69	DSV-3L
74	Skynet 1	22 Nov 69	DSV-3M
75	Intelsat 3F	14 Jan 70	DSV-3M
76	Tiros M	23 Jan 70	DSV-3N6
77	Nato 1	20 Mar 70	DSV-3M
78	Intelsat 3G	22 Apr 70	DSV-3M
79	Intelsat 3H	23 Jly 70	DSV-3M
80	Skynet 2	19 Aug 70	DSV-3M
81	Noaa 1	11 Dec 70	DSV-3N6
82	Nato 2	2 Feb 71	DSV-3L-11
83	Explorer 43	13 Mar 71	DSV-3M6
84	Isis 2	1 Apr 71	DSV-3E1
85	OSO 7	29 Spt 71	DSV-3N
86*	Itos B	21 Oct 71	DSV-3N6
87	HEOS 2	31 Jan 72	DSV-3L
88	TD-1A	12 Mar 72	DSV-3N
89	Erts 1	23 Jly 72	900
90	Explorer 47	23 Spt 72	1604
91	Noaa 2	15 Oct 72	300
92	Anik 1	10 Nov 72	1914
93	Nimbus 5	11 Dec 72	900
94	Anik 2	20 Apr 73	1914
95	Explorer 49	10 Jun 73	1913
96*	Itos E	16 Jly 73	300
97	Explorer 50	26 Oct 73	1600
98	Noaa 3	6 Nov 73	300
99	Explorer 51	16 Dec 73	1900
100	Skynet 2A	18 Jan 74	2313
101	Westar 1	13 Apr 74	2914
102	SMS 1	16 May 74	2914
103	Westar 2	10 Oct 74	2914
104	Noaa 4	15 Nov 74	2310
105	Skynet 2B	23 Nov 74	2313
106	Symphonie 1	19 Dec 74	2914
107	Erts 2	22 Jan 75	2910
108	SMS 2	6 Feb 75	2914
109	Geos 3	9 Apr 75	2410
110	Anik 3	7 May 75	2914
111	Nimbus 6	12 Jun 75	2910
112	OSO 8	21 Jun 75	2910
113	Cos B	9 Aug 75	2913
114	Symphonie 2	27 Aug 75	2914
115	Explorer 54	6 Oct 75	2910
116	Goes 1	16 Oct 75	2914
117	Explorer 55	20 Nov 75	2910
118	Satcom 1	12 Dec 75	3914
119	CTS	16 Jan 76	2914
120	Marisat 1	19 Feb 76	2914
121	Satcom 2	26 Mar 76	3914
122	Nato 3A	22 Apr 76	2914
123	Lageos 1	4 May 76	2913
124	Marisat 2	10 Jun 76	2914
125	Palapa 1	8 Jly 76	2914
126	Noaa 5	29 Jly 76	2310
127	Marisat 3	14 Oct 76	2914
128	Nato 3B	28 Jan 77	2914
129	Palapa 2	10 Mar 77	2914
130	GEOS	20 Apr 77	2914

131	Goes 2	16 Jun 77	2914	139	Landsat 3	5 Mar 78	2910
132	GMS	14 Jly 77	2914	140	BSE	7 Apr 78	2914
133	Sirio 1	25 Aug 77	2313	141	OTS 2	11 May 78	3914
134*	OTS	13 Spt 77	3914	142	Goes 3	16 Jun 78	2914
135	ISEE 1 & 2	22 Oct 77	2914	143	Geos 2	14 Jly 78	2914
136	Meteosat	23 Nov 77	2914	144	ISEE 3	12 Aug 78	2914
137	CS 1	15 Dec 77	2914	145	Nimbus 7	24 Oct 78	2910
138	IUE 1	26 Jan 78	2914	146	Natoc 3C	15 Nov 78	2914

THE COSMONAUTS

By Gordon R. Hooper

Colonel Sigmund Jähn

Sigmund Jähn was born on 13 February 1937 in Rautenkranz, near Klingenthal in the Vogtland of the German Democratic Republic, the son of a sawmill worker. At school, he was elected Pioneer class organiser, and became a member of the Free German Youth (FDJ), of which he later became Secretary. After finishing 8th Grade with the top marks of his year, he left school in 1951 to learn the trade of printer. He received his skilled workers certificate from the Falkenstein national book printing works, Klingenthal branch.

In 1955, Jähn joined the Air Force of the National Peoples Army. He attended the Franz Mehring Air Force Air Defence Officers College, and was described as a model officer cadet. In 1956, he joined the Socialist Unity Party, and in 1958 he was commissioned as a 2nd Lieutenant.

He was then assigned to a fighter squadron where he was the political officer responsible for the ideological education of the members of his unit. At the age of 26, he was appointed officer in charge of air tactics and gunnery in his squadron.

In 1966, he was sent for training at the Yuri Gagarin Air Force Academy in the Soviet Union. Out of 21 training subjects, he received 13 "Excellent" ratings, and eight "Good". He graduated in 1970, and returned to the GDR. In the period that followed, he again assumed a number of important posts in the Air Force, and in no time at all, he had again attained top class flying qualifications. He received his licence as a flight instructor for day and night training under all weather conditions for the most advanced fighter planes in service.

Space "postman" Colonel Sigmund Jähn accepts a kiss for Vladimir Kovalyonok from the latter's wife Nina.

Novosti Press Agency

He won particular distinction for the theoretical development and practical testing of new elements in the training and use of fighter forces. For his outstanding services, he was awarded the title of Distinguished Military Pilot of the GDR. He has logged over 1,000 hours of flying time.

Following the announcement of the Intercosmos agreement to fly non-Soviet cosmonauts onboard Soviet spacecraft, Sigmund Jähn was fortunate enough to become one of the two finalists chosen by GDR scientists. He went to the Yuri Gagarin Cosmonauts Training Centre in December 1976, and studied alongside other non-Soviet cosmonauts including Vladimir Remek and Miroslaw Hermaszewski.

His journey into space began with the launch of Soyuz 31 on 26 August 1978, when he acted as "cosmonaut-researcher" to Valeri Bykovsky. The Soyuz docked with the Salyut 6 spacelab, and the two men joined Vladimir Kovalyonok and Alexander Ivanchenkov onboard. They then spent nearly seven days carrying out a series of joint Soviet-GDR experiments, before returning to Earth on 3 September after a flight lasting 7 days 20 hours and 49 minutes.

Following the space flight, Jähn was promoted from Lt. Colonel to Colonel, and received many awards including the titles Hero of the Soviet Union, Hero of the GDR, and Pilot-Cosmonaut of the GDR, together with the Order of Lenin, the Gold Star Medal, and the Karl Marx Order.

Sigmund Jähn is married and his wife Ericka trained first as a fitter and then qualified as a technical draughtsman. They have two daughters, Marina born in 1958, and Grit born in 1966. Jähn's favourite hobby is reading, and he is also a passionate hunter, being a member of a German hunting club. He is also described as a nature lover.

He is said to be "strong-willed, single-minded, resolute, and has the capacity to react swiftly in unforeseen circumstances". Alexei Leonov has described him as "an unusually uncomplicated man – a man of great principles and integrity".

Colonel Eberhard Kollner

Eberhard Kollner was the GDR's other cosmonaut, born on 29 September 1939. He underwent the same selection and training procedures as Jähn, but few biographical details have been released. Kollner served as back-up to Jähn, and acted as CapCom during the mission, using the callsign Terek-2. Following the successful completion of the flight, he was promoted from Lt. Colonel to Colonel, and was awarded the GDR's highest military award, the Scharnhorst medal.

SPACE REPORT

A regular monthly review of Space Events and Technical Trends

BAe SOLAR ARRAY MAST

British Aerospace Dynamics Group at Bristol have successfully completed deployment tests of a telescopic solar array mast under development for satellite applications. The successful operation of the 3-element mast, which, fully deployed extends to 5.5 metres (18 ft), is a major milestone in the development of a lightweight hybrid solar array for the European Space Agency that may be used for direct broadcast television satellites in the mid-1980s.

A hybrid array combines small rigid solar panels supplying power during the transfer orbit of the satellite with much larger deployable, flexible panels providing the main geostationary, or operational orbit power.

In design, the 3-element mast is fully representative of a 9-element 16 metre (52 ft) flight standard mast which is nearing completion and will be tested later this year. Such masts will carry flexible fold-out membranes covered with solar cells to produce typically 6kW of power for television broadcast satellites. The telescopic elements of the mast are extended using stored nitrogen gas and their deployment is controlled by an escapement mechanism.

The latter is very similar to that developed by British Aerospace in the mid-1960s for the British scientific satellite Ariel 3 to control the deployment of its rigid solar paddles. This design proved so successful in operation that it has been used subsequently on Ariel 5 and Ariel 6.

EUROPEAN LUNAR ORBITER?

Following the success of the GEOS 2 geostationary scientific satellite, launched in July 1978, engineers at British Aerospace Dynamics Group at Bristol have been investigating, under contract to the European Space Agency, the possibility of producing a further similar satellite—GEOS 3. It would be based upon the same design and largely utilise existing hardware.

The Bristol Group recently submitted four possible scientific missions any one of which could be selected. The European Ariane launch vehicle would be used to put GEOS 3 into orbit as a co-passenger with a geostationary communications satellite.

In Mission 1, GEOS 3 would orbit the poles of the Moon. A particular aim of this mission would be to try to detect ice in the permanently shadowed polar regions.

Mission 2 also orbits the Moon from where the Earth's magnetotail can be studied. The payload would be very similar to that of GEOS 2.

The third mission is an Earth orbit which uses lunar gravity to rotate the orbit by 360 degrees each year and so keep the satellite in the Earth's magnetotail.

In mission 4—a magnetotail mission—GEOS 3 would be placed in a little known region 1.5 million kilometers from Earth at a point where the pull of Earth and Sun gravity is balanced by the satellite's orbital motion. A possible decision on the realisation of the project is unlikely before February.

PROJECT FIREWHEEL

During March 1980, residents of North and South America will be able to observe a man-made comet, writes Gerald L. Borrowman. Project Firewheel will reveal secrets about the Earth's environment by detonating canisters of barium and lithium about 60,000 km. above the Earth. The project is being conducted jointly by the US National Aeronautics and Space Administration and the European Space Agency.

The Firewheel satellite will be launched atop the Ariane rocket from Kourou, French Guiana, near the forbidding shell of Devil's Island penal colony. The satellite consists of a main bus which carries four ejectable satellites loaded with instruments to monitor the barium and lithium explosions. The total mass is 1,100 kg. (including a contingency of 150 kg.) of which 200 kg. comprise the four sub-payloads and 320 kg. the chemical release experiments. The main payload as well as the ejected release containers and sub-payloads are spin-stabilised.

The launch will occur next March during 10 consecutive nights around the new Moon and the experiment will be conducted on the first night after launch when the light levels are low during the satellite's apogee.

Weather permitting, the barium cloud will appear like a spectacular comet. The information collected by the four small satellites will be recorded at Earth receiving stations. The experiment will last for about 40 hours. Scientists with airborne teams from the US and Argentine air forces will measure the effects of the disturbances on the Earth's atmosphere and the energy field. These observations will be made aboard aircraft at the equator and around the polar regions.

This will probably be the largest single international experiment to be performed in space, but will probably turn out to be the cheapest. The total cost of the project will be several million dollars.

SPACE SHUTTLE FOOD

When operational flights of the Space Shuttle begin in the early 1980s, astronauts will find themselves eating improved meals which have been largely unknown to previous space crews, writes Keith T. Wilson. This is due to recent research carried out at the Office of Space and Life Sciences at Johnston Space Center.

Shuttle food will be a far cry from the tubes of pastelike food and lukewarm rehydrated cubes which astronauts consumed in the early days of spaceflight.

Six types of foods have been planned for the Space Shuttle.

- Thermostabilized - Thermal/heat processed foods canned or packaged in foil pouches such as cheese spread, tuna, beef with barbecue sauce.
- Intermediate Moisture - Foods preserved by controlling the available moisture, such as dried apricots, peaches.
- Rehydratable - Foods reconstituted with water, such as scrambled eggs and all beverages.
- Irradiated - Foods exposed to ionizing radiation to effect preservation, such as bread, rolls and beef steak.
- Freeze-Dried - Foods with all water removed, such as strawberries and shrimp.
- Natural - Such as nuts and cookies.

Shuttle astronauts will have a much greater variety and larger amounts of food; over 70 types of food and 20 beverages will be available. Caloric content has been raised from Skylab's 2,800 to 3,000 for the Shuttle as tests have shown that working astronauts need the same caloric intake as groundbased workers. All Shuttle meals

will be prepared with variety in mind. The astronauts will have a different menu for six successive days with the cycle beginning again on the seventh day.

Handling of food will be much more efficient. An oven will operate in the galley and will be able to heat meals to 85°C and hold temperature levels at 65°C. Meals aboard Skylab were often not hot because of problems with temperature control due to the low pressure inside the space station. The oven will be capable of heating food containers constructed from different materials and of different shapes and sizes.

Up to date versions of Skylab's food trays will be used. They will be more streamlined, easier to eat from and will be able to maintain heat more efficiently for hot foods while not affecting the temperature of cold items. Food will be eaten with conventional utensils.

The dining area of the Space Shuttle, located below the flight deck, has apart from the oven, a pantry, a dining table and a unit for washing up which includes hot and cold running water. However, a refrigerator will not be available until additional space and power supply become attainable. This unfortunately means that ice cream, which was the favourite food aboard Skylab, will not be served aboard the Shuttle.

ARIANE HOLD-DOWN SYSTEM

The £1.85m contract to design, supply and test the vital hold-down release system for the Ariane space launcher has been completed by the Stevenage Space facility of British Aerospace Dynamics Group. The hold-down system comprises four hydraulically-actuated quick-release retaining arms with the associated control electronics. The arms restrain Ariane on its launch pad when the rocket motors are developing their full power. When release is initiated, the control system ensures that the arms release and retract in synchronisation.

The system has been installed and completed all its acceptance tests at the Ariane launch site in Kourou, French Guiana, ready for the first launch scheduled in November. Structural and flexure tests on a single arm assembly were completed at the Stevenage Space facility.

The contract for the Ariane hold-down launch system was obtained by British Aerospace Dynamics Group in competition with other international companies. The design is based on a similar system developed for the British Blue Streak rocket. A proven concept and practical experience were factors influencing the selection of the British Aerospace system.

British Aerospace Dynamics were sub-contractors to the Centre National d'Etudes Spatiales (CNES) for this project.

ARMSTRONG FAVOURS SPACE STATION

Neil Armstrong suggested a small step for the US space programme would be the development of a permanent manned orbiting space station. "I believe it would be affordable, productive and comparable with the Shuttle. Such an effort would provide the opportunity for long duration exposure of people and equipment to the space environment and garner the confidence necessary prior to the inevitable manned planetary expeditions of the future".

During the news conference held on 11 June 1979, in Cincinnati, Ohio, held to elicit his comments on the upcoming 10th anniversary of his historic flight to the Moon, he fiddled nervously with a paper clip as he responded to more than 75 questions from his thoughts on the Moon landing to how his wife and family have coped with his success, writes Gerald L. Borrowman.

Answering a question pertaining to the problems with Skylab, Armstrong said, "We could have solved the problems with Skylab that we are facing, I believe, if we had an active and ongoing manned space programme".

Recalling his thoughts from a decade ago when he, along with astronauts Edwin "Buzz' Aldrin and Mike Collins, went to the Moon, Armstrong said, "I would have to say for me the most exciting part wasn't walking on the Moon, but the descent to the Moon with the lunar lander. In my personal opinion, that was the most challenging and exciting part of the mission because it proved we could get there".

The former astronaut, looking physically fit in a brown suit, said America needs a new commitment to its space programme, and added: "Maybe we just had too many successes and people began taking us for granted. It might take something significant to get people back to thinking about space".

Armstrong said he would like to go back to visit the Moon again. "I would do it again. I think many of my fellow astronauts would answer the same way".

SPACE PLATFORM STUDY

NASA has awarded a study contract to define a space platform for geostationary Earth orbit that would allow a large number of separate payloads to be economically clustered together on a single orbiting structure. The NASA Marshall Space Flight Center, Huntsville, Alabama, awarded the contract to General Dynamics Convair, San Diego, for a study to determine the feasibility and define the systems for such a platform.

Comsat Corporation of Gaithersburg, Maryland, will be the major sub-contractor. Total amount of the study contract is $250,000.

The orbiting platform could be host to plug-in devices for communications, Earth resources, meteorology and numerous scientific investigations like those currently flown as self-contained satellites.

Preliminary studies done by Marshall indicate it would be feasible for such a platform to be constructed in space and placed in an orbit synchronised with the Earth's rotation. There it could provide electrical power, stabilisation and housekeeping functions to various tenant mission devices parked on it, in return for a use fee, not unlike rent.

Previous studies indicated that geostationary platforms might offer many benefits over today's individual specialised satellites. The platform's common services, available to all tenants, would eliminate the need to put antennae, batteries or solar power arrays on each individual device, thereby reducing the size and launch weight of each. The centralised location of a number of packages on one platform would also make on-orbit repair work and servicing easier to conduct.

Communications satellites, in particular, could benefit from a platform approach. It would reduce crowding in the high traffic areas of space, provide more efficient use of available frequencies, and make it possible to use smaller, less expensive ground terminals.

Eventually, platforms might be located at several positions around the globe to serve the needs of densely populated areas such as the United States, South America, Western Europe and India. Communications links might be established between these platforms, allowing around-the-world communications without the need for relaying through ground terminals.

SATELLITE OBSERVES SUPERNOVA

The scientific satellite, IUE, has been used by a team of European astronomers to observe a supernova. Supernovae represent the final explosive stages of the life of certain stars. These phenomena are very rare and are only observed about once every 30 years in our Galaxy. Although several are known to occur every year in the Universe, most are barely visible because they lie in distant galaxies.

The supernova under observation was discovered by an American amateur astronomer on 19 April and is located in the Messier spiral galaxy 100 at a distance of about 100 million light years from the Earth. Its existence was confirmed two days later by Dr Franco Ciatti of Asiago Observatory near Vicenza in Italy. This supernova is the brightest observed from the Earth since 1971. Observations with the IUE satellite were started immediately at the European Space Agency's tracking station at Villafranca near Madrid, where Dr Nino Panagia of the Radioastronomy Laboratory, Bologna (Italy) began analysis of the data.

IUE is a joint project of ESA, NASA and the United Kingdom Science Research Council. It contains a telescope of 45 cm diameter aperture and spectrographs for ultraviolet astronomical spectroscopy. The satellite is controlled 8 hours a day from ESA's Villafranca station.

GALAXY WITH TWO NUCLEI

An unusual galaxy with two nuclei has been discovered as a result of a lengthy international experiment which drew together radio astronomers of the USSR, the Federal Republic of Germany, the United States and Sweden.

Assessing the results of this global experiment, Iosif Shklovsky, corresponding member of the USSR Academy of Sciences, says that the value of this discovery lies in the fact that it is the first time that scientists have observed a phenomenon of this kind. Hitherto the existence of galaxies with double nuclei had only been predicted by theoreticians. In his opinion, the mass of these nuclei is 3^{10^8} times the mass of the Sun, while their dimensions are not less than one light year. This makes it possible to suppose that the nuclei are huge "Black Holes".

The experiment was conducted with the aid of a global system of radio telescopes–that of the Crimean Astrophysical Observatory (the USSR), the telescope of the Max Planck Institute (Federal Republic of Germany) and three American instruments and a Swedish one. The signals received were recorded and processed by computers.

The studies of galaxies and nebulae where new stars are being formed are continuing and it is planned that scientists of Britain and the Netherlands will take part in future experiments.

ARABSAT

A satellite communications system to meet the growing needs of the rapidly-developing Arab states has been put forward by the Dynamics Group of British Aerospace.

ARABSAT would be based on the European communications satellite (ECS) for which Dynamics Group is prime contractor to the European Space Agency.

ECS, scheduled for launch in 1981, will provide Europe with a fully-operational regional communications system from Space.

ARABSAT would carry main television, radio, telephone, telex and data communications as well as local TV and radio.

The satellite would have up to 23 channels, each of which could handle up to 700 telephone calls simultaneously or two TV programmes.

Dynamics Group introduced their ARABSAT proposals to the Arab world at the Mecom 79 exhibition in Bahrain last April.

EUTELSAT HIRES ECS

Interim Eutelsat, the organisation of European telecommunications administrations, has signed an agreement with the European Space Agency for use of a regional communications satellite system to be known as ECS. The various member countries will provide ground stations.

The ESA-supplied space segment will include a number of satellites built by the MESH consortium led by British Aerospace Dynamics. Two European Communications Satellites (ECS) will be in geo-stationary orbit simultaneously between 10^{o}-12^{o} longitude (one serving as back-up) and each will be capable of carrying 12,000 telephone calls, plus two TV channels intended for the Eurovision service of the European Broadcasting Union.

The first satellite is expected to be launched by Ariane at the end of 1981, the second following 10 months later, ESA plans to buy a total of five satellites to meet requirements of the system during a 10-year period. Contracts for the three other satellites are being negotiated.

VECTORING THE SRBs

Two thrust vector control (TVC) systems that will steer the Space Shuttle's twin solid rocket boosters (SRBs) have been successfully 'hot fired' at the Kennedy Space Center. The TVCs are installed in the aft skirt of the SRBs that will participate in the Shuttle's maiden flight.

The TVC system employs a hydrazine-driven turbine that operates a hydraulic pump connected to two electromechanical servo-activators. In the final 20 seconds before launch, the TVC system will be activated and the launch processing system (LPS) in the Launch Control Center will send electrical signals to the servo-actuators. After liftoff, the Space Shuttle Orbiter will electrically command the servo-actuators' pistons to extend or retract their rods to exert mechanical force on the SRB's nozzle to change flight direction.

After TVC hot firing, the aft skirts were returned to the Vehicle Assembly Building for stacking with other SRB segments, including live solid propellant motors, on the mobile launch platform.

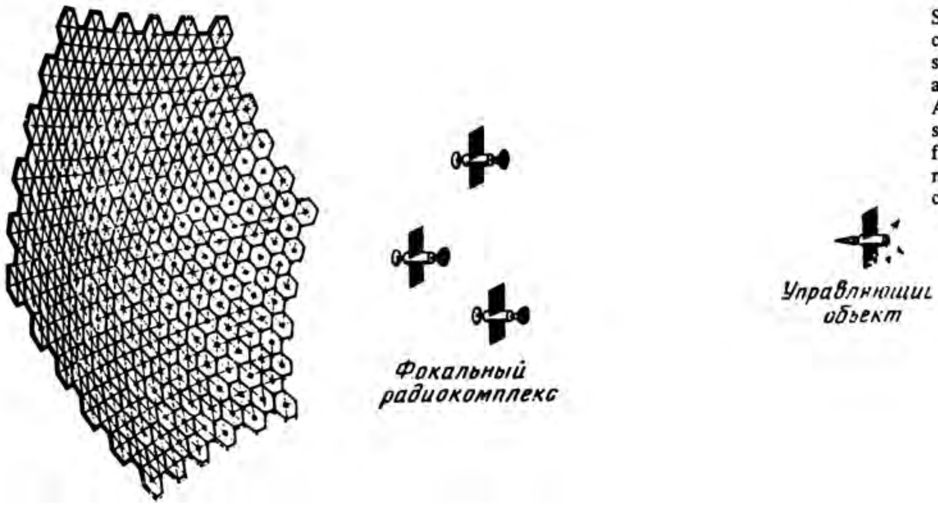
FLIGHT CONTROLLER AT AGE 18

At age 18, Jackie Parker is the youngest flight controller in the history of manned spaceflight. She is also among the first group of women to man a console in the Mission Control Center at the NASA Johnson Space Center.

"I work in support of the DPS (Data Processing Systems) console", she says. "I'm in that position during ascent phase, which is launch and the first few hours of orbit". Her post will be in the Mission Operations Control Room during forthcoming Space Shuttle missions.

Eyes fixed on the console, Jackie will monitor and respond to the five computers onboard the Space Shuttle. Like other controllers, she interacts with the computers for data to be uplinked or downlinked by telemetry.

During a Shuttle mission, she and other controllers in her section assess the health of the onboard and on the ground computer system which, in essence, controls major parts of the orbiting vehicle.



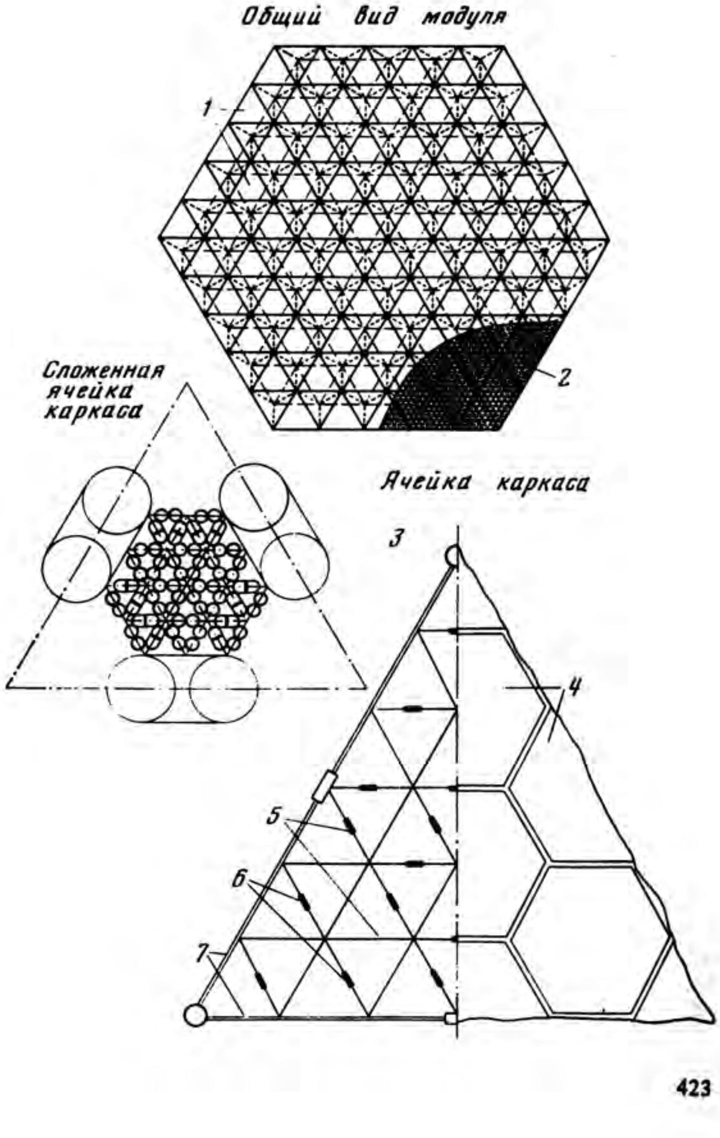
SPACE TELESCOPE. Observations could begin with the assembly of a spherical antenna of 3 km. diameter as shown in this Soviet sketch. Automated spacecraft keeping station with the dish act as antenna feeds; at extreme right is the control module with facilities for communications with Earth,

A GIANT SPACE TELESCOPE of up to 10 km. diameter–assembled from 200 metre modules–has been proposed by 23 Soviet space engineers and astronomers. Their report, "The Infinitely Built-up Space Radio Telescope", was reviewed in the March issue of *Spaceflight* by Boris Belitsky.

If operated as an interferometer with a baseline of 20 AU and working at wavelengths of a few centimetres, in theory two such instruments could produce holograms or three-dimensional images of the Universe. They could search the wavebands for evidence of extra-terrestrial civilizations.

Right, unit construction of telescope reflector. *Key:* 1. Power frame; 2. Working surface; 3. Power frame connectors; 4. Regulating shields of reflecting surface; 5. Rods of working surface; 6. Connectors of flexible rods; 7. Rods of power frame.

Novosti Press Agency



SATELLITE DIGEST - 130

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed summary of the information presented can be found in the January 1979 issue, p. 41.

Continued from August/September issue]

Name designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Fleetsatcom 2 1979-38A	1979 May 4.789 indefinite	Hexagonal cylinder 1884 fuelled	1.27 long 2.44 dia					ETR Atlas Centaur USN/NASA (1)
Progress 6 1979-39A 11356	1979 May 13.178 27 days 1979 Jun 9	Sphere + cone- cylinder 7000	8 long 2.2 dia	190 307 322	247 333 340	51.62 51.61 51.63	88.80 90.86 91.09	Tyuratam A-2 USSR/USSR (2)
Cosmos 1098 1979-40A 11358	1979 May 15.49 13 days (R) 1979 May 28	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	168	356	72.87	89.79	Plesetsk A-2 USSR/USSR
Cosmos 1099 1979-41A 11360	1979 May 17.30 13 days (R) 1979 May 30	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	214 208	244 233	81.34 81.35	89.14 88.97	Plesetsk A-2 USSR/USSR (3)
Cosmos 1100,1101 1979-42A, B 11362, 11363	1979 May 22.96 1 orbit? (R) 1979 May 23	Cylinders? 7000?	7 long? 2.5 dia?	195	210	51.6	88.5	Tyuratam D-1 USSR/USSR (4)
Cosmos 1102 1979-43A 11367	1979 May 25.28 13 days (R) 1979 Jun 7	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	211	259	81.34	89.26	Plesetsk A-2 USSR/USSR (5)
1979-44A 11372	1979 May 28.77 6 months	Cylinder 13300 fuelled?	15 long? 3.0 dia	133	291	96.41	88.80	WTR Titan 3D DoD/USAF (6)
Cosmos 1103 1979-45A 11376	1979 May 31.68 14 days (R) 1979 Jun 14	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	255 325	374 416	62.82 62.82	90.89 92.01	Plesetsk A-2 USSR/USSR (7)
Cosmos 1104 1979-46A 11378	1979 May 31.75 1200 years	Cylinder + boom 700?	3 long 2 dia	961	1009	82.95	104.85	Plesetsk C-1 USSR/USSR (8)
Ariel 6 1979-47A 11382	1979 Jun 2.976 60 years	Cylinder + dome + 4 panels 154	1.308 long 0.696 dia	599	656	54.95	97.19	Wallops Island Scout D UK/NASA (9)
Molniya-3 (12) 1979-48A 11384	1979 Jun 5.98 12 years?	Cylinder-cone + 6 panels + antennae 1500?	4.2 long? 1.6 dia	438 444	40772 39913	62.84 62.86	735.18 717.88	Plesetsk A-2-e USSR/USSR (10)
Soyuz 34 1979-49A 11387	1979 Jun 6.76	Sphere + cone- cylinder 6800?	7.5 long 2.2 dia	192 231 289 351	254 301 364 363	51.61 51.61 51.61 51.63	88.90 89.77 91.00 91.61	Tyuratam A-2 USSR/USSR (11)
AMS 4 1979-50A 11389	1979 Jun 6.76 100 years	Irregular box + panel 513	6.4 long 1.7 dia	818	837	98.78	101.52	WTR Thor Burner 2 DoD/USAF
Bhaskara 1979-51A 11392	1979 Jun 7.43 10 years	26 faced polyhedron 360	1.19 high 1.55 dia	519	541	50.67	95.16	Kapustin Yar C-1 India/USSR (12)
Cosmos 1105 1979-52A 11394	1979 Jun 8.30 13 days 1979 Jun 21	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	210 211 209	246 250 232	81.33 81.35 81.35	89.12 89.17 88.96	Plesetsk A-2 USSR/USSR (13)

Supplementary notes:

(1) Second in series of military communications satellites for use by ships and soldiers in the field.

(2) Unmanned supply craft carrying food, materials and fuel to Progress 6. Launched at 0417 UT on May 13, Progress 6 docked at 0619 on May 15. Undocking occurred at 0800 on Jun 8, after which Progress 6 flew alongside Salyut during the docking of the unmanned Soyuz 34. Progress was de-orbited over the Pacific Ocean. Orbital data are at 1979 May 13.3, May 13.5 and May 16.6.

(3) Manoeuvrable reconnaissance satellite carrying an Earth resources package. Orbital data are at 1979 May 17.4 and 19.1.

(4) Dual launch of spacecraft, recovered immediately. See also

Throughout the text examples and applications such as the grey atmosphere, Wolf Rayet atmospheres, etc., are discussed. Also the theory described is illustrated by calculations and diagrams relating to particular problems. (The computing methods used are also mentioned). These examples are also compared with observations. The text is also dotted with problems for the reader which extend the book.

References are collected at the end of the text along with a detailed glossary of symbols (which are very useful if you use the book for reference purposes). The index is extensive and complete.

This is definitely the book for the specialist and I would expect most astrophysicists to already know about it (and probably own their own copy as it is very good value for money).

C.A. WHYTE

Images from Space—Camera in Orbit
By H.J.P. Arnold, Phaidon Press, 64 pp. £12.95.

This is a large-format collection of space pictures published to coincide with the 10th anniversary of the first lunar landing on 21st July 1969.

A total of 64 pictures have been included (some in colour) grouped under the headings of "Machines", "Men", "Earth", "Worlds Beyond" and "Reality is Fantasy".

The illustrations are well selected, varied and very interesting, though captions do not appear under each but are grouped together in the front of the book.

The fact that pictures appear on each side of the same sheet, may deter some from extracting their favourites for framing, and one wonders why the publishers did not select some of the more attractive pictures to include separately on good-quality art paper for just this purpose.

Those familiar with some of the pictures, e.g. Ed. White in the spacewalk on Gemini IV, might feel disappointed to see it reproduced in black and white. The same applies to the marvellous photograph of the Indian sub-continent and also to the Earth rising over the lunar horizon. This, beyond doubt, reflects the enormous cost of reproducing pictures in colour nowadays.

L.J. CARTER

The All-American Boys
By Walter Cunningham, Macmillan, New York, S9.95.

Walter Cunningham successfully delineates why men serve as astronauts and how they were altered by that experience. The three fundamental challenges to astronauts are, first, the challenge of man against the machine. The astronauts had to master Apollo, the most complex piece of machinery ever constructed. Secondly, man against man. The astronaut corps is one of the most competitive groups ever assembled. Thirdly, the synthesis of the airplane cockpit and the spacecraft. As these ingredients form the warp and the woof of the book, so it stands as a guidepost for those who will participate in the supreme adventure of reaching out into the Solar System.

From his years as an astronaut Cunningham recounts a story of intrigue, irony and pathos. Beginning with an intimate account of the Apollo 204 accident, Cunningham recounts the day-to-day life of an astronaut. He reveals the personalities and many insightful incidents that were a part of the struggle to ensure the flight-worthiness of Apollo. The candid account of Apollo 7 is particularly engrossing. As a background he describes the glamorous series of social functions and the domestic and emotional upheavals. All this serves to pierce the public relations curtain that NASA so carefully sought to erect before the eyes of the public. This campaign extended even to the deletion of negative comments made by the crew about spacecraft hardware in the post-flight reports.

The result: an engrossing account of a man's endeavour to reach the Moon. A story that deserved to be told.

GERALD L BORROWMAN

'Skylab: A Chronology'
By Newkirk, Ertel and Brooks, NASA SP-4011, pp458, US Government Printing Office, 1977, S7.00.

Although part IV of the Apollo spacecraft chronology has not yet appeared, the Skylab chronology has been published. The usual pattern of recording major NASA projects is to be followed by concentrating on the chronology first, getting the facts straight and putting them into chronological order, and then filling them out into a full history.

The Skylab chronology is split into three sections: the first, from 1923 to July 1965, covers early space station concepts (beginning with Oberth's proposal of 1923); the second looks at the Apollo Applications Programme era when the hardware contracts were let out and Skylab evolved into a form much as we know it today; the third takes the story from February 1970 when the name Skylab (suggested by Donald L Steelman of the USAF) was adopted, through its constructional and operational phases and up to November 1974. The end date means that much of the scientific analysis is lost but that does not detract from the importance of the chronology.

Curiously, it is usually the case that a project chronology contains more interesting illustrations than the project history and this chronology certainly has plenty of interesting photographs and diagrams. There is also an appendix listing the IAF world records achieved by US manned missions; Skylab, of course, won many records of its own.

It is a matter of opinion as to how detailed a document of this kind should be but the reviewer felt there was a lack in some areas. A particular type of case occurred repeatedly when astronauts were described as having taken part in some activity but without giving their names. Also, the Mercury chronology gives a listing of suggested dispositions for hardware left over from the project and it would have been nice to see such a list here.

A work of this kind invariably contains a few mistakes but the only one noted is on p166 where 'AL7' should read 'A7L'.

The chronology is a valuable contribution to the history of spaceflight and we can all look forward to the narrative history with anticipation.

ANDREW WILSON

Descriptive Astronomy
By R. M. Berg and L. W. Fredrick D. Van Nostrand Company, 1978, pp.+323.

The title appears either singularly uniformative as to the contents of the book or actually indicates a text as broad as its title is short. In fact, it is the latter course which the authors are set to negotiate. It is almost surprising, in view of the exponential growth in astronomy in recent years, that a work intended to encompass virtually every principal facet of such a wide-ranging science should still be attempted (in this case for consumption by the layman). The breadth of

the text is certainly large, and this is possibly not a wise concept. Whilst there appears little that is not mentioned, at least, this could be a drawback for no topic is dealt with in any significant depth. However, this is clearly a matter of personal preference.

The book is primarily intended for 'non-science college students', although being of trans-Atlantic authorship it is not clear from this just what age of student is aimed at. On the one hand, for example, technicalities such as principles of spectroscopy are introduced, whilst at the end of each chapter there are (to my mind) unnecessary 'review' questions, and a very short and seemingly irrelevant section of supposedly common 'fallacies and fantasies'. I can only think that these are primarily the product of the authors' imaginations, as I, for one, was not aware that the following (which I cannot resist quoting) are common misconceptions:

the speed of light is infinite;
the Sun is the largest star;
the Pleiades is the Little Dipper;
the Sun burns coal to produce its energy;
the Sun is an old star near the end of its life;
the Sun is a young star;
stars only live to be about a hundred years old;

and other such strange and badly expressed 'fallacies' as:

red stars are hot;
all stars are the same brightness;
the Earth is a large planet;
straight lines are straight.

These I found the most fascinating aspect of the book! With a 'personal observing log' for entering observations of planets, constellations, meteors etc. at the end of the text, I presume that the book is for pre-university students (although it would seem a pity to spoil such a well produced volume with personal notes).

Having said this, it is nevertheless true that the book is very informative and will be reasonably easy to follow for the non-technical reader, with mention of very up-to-date aspects of astronomy. However, the overly-chatty style can be somewhat misleading. For example, the first chapter dealing with the creation of the Universe launches, with no preamble, into an apparently factual blow-by-blow account of the beginning of the Universe from the moment of the Big Bang. All very absorbing, but it is only when one reaches the summary at the end of the chapter that the unwary reader is told that the account is not fact, but hypothesis. Not only do the authors deal laterally with all major topics enveloped by modern astronomy, but also vertically through the history of the science, although at £12.10 the book is undoubtedly very expensive and it follows the style of layout with 2/3 of the page accommodating the main text with a 1/3 page margin used for occasional diagrams and annotations (but more usually left blank). Although this form of pagination appears to be much favoured for lavish 'popular' texts, it must surely add unnecessarily to the cost of the book. Nevertheless, the text is handsomely produced and is particularly well illustrated with a considerable number of colour plates (including the familiar and magnificent Hale Observations series of colour photographs of galaxies and nebulae), and the above reservations do not detract seriously from an otherwise authoritative summary of modern astronomy. However, certain inconsistencies creep into the text; for example, why the light-year is used as a measure of distance and the parsec not even mentioned is puzzling, especially as the authors are professional astronomers.

S. G. SYKES

The Partnership: A History of the Apollo-Soyuz Test Project
By E C and L N Ezell, NASA SP-4209, US Govt. Printing Office, 1978, pp 560, S8.30.

'We have capture . . . okay, Soyuz and Apollo are shaking hands now'. With these words Soviet cosmonaut Alexei Leonov described the climax to the years of preparation and effort that had gone into planning the most spectacular and expensive of international ventures—the linking of two manned Soviet and American spacecraft in Earth orbit in the summer of 1975.

The early years of the space age saw a great deal of rivalry between the two space nations but after it became clear that Apollo II would give the Americans the ultimate propaganda victory the race became less heated. Lunar samples from Apollo 11 and Luna 16 were exchanged and when Nixon became President in 1969 the way was open for Soviet-American cooperation.

The first real discussions relvant to this history took place in October 1970 when Gilruth and Lunney of NASA went to Moscow where a general agreement on a joint flight was reached and the two sides even got down to the technical details of the docking problem. At this stage a likely mission candidate was Soyuz-Skylab.

After the existence of Salyut was revealed in April 1971 the planning was switched to include that vehicle and in the following June joint working groups in Houston decided to base their studies on Soyuz-Salyut-Apollo with possibly a later flight of Soyuz-Skylab (dropped at the end of 1971).

It came as something of a shock to the Americans when the Russians unilaterally dropped Salyut in April 1972 from the planning, saying there was only one docking port on the space station. Thus, the final form of Soyuz-Apollo came about just before Kosygin and Nixon signed the agreement that put ASTP on a concrete basis in May 1972.

The engineers soon found the management side of ASTP to be more troublesome than the hardware development. Not only did they speak very different languages but each side had evolved its own space terminology and, of course, there was a large distance between the two countries.

There were some misunderstandings and setbacks, though generally the Soviets were keen to supply all the data necessary and they fully explained the causes of the Soyuz 11 and 18A failures to their counterparts. They also agreed to show the Soyuz launch live—the first time either the outside world or their own countrymen had seen such a launch.

When Apollo and the less sophisticated Soyuz spacecr docked on 17 July 1975, carrying five astronauts and cosmonauts, the story virtually came to its end. The book describes the story outlined here in great detail but not to the detriment of the spirit of the project. The actual mission description occupies only a relatively short section towards the end but the lengthy background is vital to a full understanding of the events of 1975. The authors had the advantage that the project was a complete section of Apollo in itself and they could work on the history while the planning was still in progress.

This is possibly one of the best NASA histories; it contains all the details one could reasonably expect in a book of this size, yet the technical side does not get in the way of the storytelling. The authors are to be congratulated on doing such a fine job—it is it be hoped they are working on further projects.

The only factual mistake noted is on p318 where astronaut Robert Crippen is described as the backup Command Module Pilot. Evans filled this post and Crippen was a member of the support team.

ANDREW WILSON

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The Council seeks help from all members, both in the U.K. and overseas, who would like to help us to build up a collection of Technical Reports, specialised books and reference material on space research and technology, astronomy, and closely-related items such as space law, exobiology, etc. Donations of books, reports, photographs, films, recordings, paintings, models—in fact, any similar space-related publications or small artifacts, especially those likely to be of lasting value and which might form the basis for building up an Archive Collection, would be welcomed.

In view of the need to keep room available for later growth, collections of periodicals, popular books on astronomy or space, books not specifically related to our interests, or general books in foreign languages, cannot be accepted. Since we need to build up a "balanced" collection, members wishing to donate items are asked, in the first instance, to send details to the Executive Secretary, who is responsible for co-ordinating this part of the Society's Development Programme.

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As a new activity to support its Development Appeal the Society is issuing a special package of saleable items to boost fund-raising to pay for its new HQ building. Each item is stamped with the name of the Society in gold foil, many with its motif too.

Each package contains two 6" polypropylene combs, eight black lead pencils, two bookmarks, eight stylo ball pens, two 30 cm plastic rulers, two key fobs, four note-pads and one "Chiltern" diary in PVC wallet – the complete package is for sale at £4.00 ($10.00) post free.

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(Red-Cover issues of JBIS)

Members may order the 1980 "Interstellar Studies" issues of *JBIS* (Red Covers) either separately by remitting directly, or by adding the appropriate amount to their Subscription Notice.

Five issues will appear in 1980, one being an enlarged Special issue containing a completely revised and updated "Bibliography of Interstellar Travel & Communication".

The cost of the five issues is £7.00 ($16.00). The "Bibliography" may be ordered individually, if desired: its price is £2.00 ($5.00) post free.

Those who wish to start their collections of Interstellar Studies issues from now might like to know that a small quantity of back issues from 1977-1979 is still available.

Orders and enquiries to be sent to the Executive Secretary, the British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

3rd BIS CONFERENCE ON INTERSTELLAR STUDIES

The Conference will be held in the Chemistry Lecture Theatre, University College, London, W.C.1. on **11-12 September 1979.**

A preliminary list of papers is as follows:

The Evaluation of Extraterrestrial Biotas by J. Armitage

On the Improbability of Intelligent Extraterrestrials by A. Bond

The Possibilities of Extra-Solar Planet Detection Offered by Future European Space Projects by R. Buckland

Computers and Intelligence by E. Coffey

The Starship Captain as Leader/Manager by T. Grant

Propulsion Requirements for a Quantum Interstellar Ramjet by H. Froning

Through the Seventh Gate: A Delphic View of Mankind's Interstellar Future by A. Martin

A Strategy for Interstellar Colonisation Missions by G. Matloff and E. Mallove

Design of a Laser Communications Receiving Station for Interstellar Signals by M. Ross

Multiple Propulsion Concept: Theory and Performance by G. Vulpetti

Resolving the Fermi Paradox by G. Webb

Applications for registration forms and notification of the intention to submit a paper for the Conference should be made to the Executive Secretary of the Society.

Lecture

Title: **BEYOND SATURN** by Dr. G.E. Hunt.

To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **9 October 1979,** 7.00-9.00 pm.

Admission tickets are not required, Members may introduce guests.

BIS ANNIVERSARY SUPPER

To be held in the Surrey Hall, Binfield Road, Stockwell, SW4 (200 yards to the left of the exit from Stockwell Underground Station, on the Victoria Line) on **19 October 1979** at 6.30 for 7.30 pm.

An informal get-together for members, their families and friends to mark the 46th Anniversary of the founding of the BIS.

Tickets are available from the Executive Secretary at £1.50 each. These cover the cost of a buffet supper, excluding drinks, and also admit bearer to view the Society's Conference Room and Library, now being set up at 27/29 South Lambeth Road, London, SW8, from 5.30 to 6.30 pm. on that date.

3rd Computers/ Space Technology Conference

Theme: **IMAGE PROCESSING TECHNIQUES APPLIED TO ASTRONOMY & SPACE RESEARCH**

To be held at the SRC Appleton Laboratory, Ditton Park, Slough, Bucks on **15-16 November 1979.**

A preliminary list of papers is as follows:

Image Processing of Faint Solar Flare Phenomena by D. L. Glackin

The Detection of Linear Features Using LANDSAT Data by C. M. Gurney

NOD-2; a General System of Analysis for Radioastronomy by C. G. T. Haslam

Application of Image Processing Techniques to Studies of Meteorology of Jupiter by G. E. Hunt

Voyager Image Processing at the Image Processing Laboratory by P. L. Jepsen

Multispectral Enhancements for Astronomical Images by J. J. Lorre and R. E. Pomphrey

A Processor for Compression of Multispectral Image Data On-Board Remote Sensing Satellites by E. Mattsson.

Three-Elementary Tools in the Processing of Remote Sensing Data: A Unifying Approach by N. J. Mulder

Image Processing for the ESA Faint Object Camera by F. Norris

High Throughput Image Processing Systems for Earth Resources Imagery by P. Redstone and D. Stanley

The Use of B-Spline Approximation and of an Array Processor in the IRAS Group Operations and Preliminary Analysis Facility by J. Renes and D. Beintema

Offers of papers (including a 300-500 word abstract of the proposed paper) should be sent to the BIS Executive Secretary, 27/29 South Lambeth Road, London, SW8 1SZ, England.

Lecture

Title: **THE INTERNATIONAL SOLAR POLAR MISSION**
by D. Eaton (ISPM Project Manager)

To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **21 November 1979,** 7.00-9.00 p.m.

Admission tickets are not required. Members may introduce guests.

SOLAR ECLIPSE JULY 31ST 1981

The Southern California Branch is interested in making up a group-expedition to view the solar eclipse on 31st July 1981. A tour of about three weeks in duration is envisaged, flying from Los Angeles with connections from the United Kingdom, and continuing via Ulan Bator, Ulan Uda to the vicinity of Novosibirsk for the viewing, thence with return to Warsaw via Soviet Georgia, for the flight back to the UK/USA.

Arrangements will be in the hands of Mr. R.V. Frampton, Mail Stop 264-519, Jet Propulsion Laboratory, Pasadena, California 91103, USA.

Members interested should contact Mr Frampton for inclusion in the preliminary list of participants.

The total cost will be dependent upon the numbers participating.

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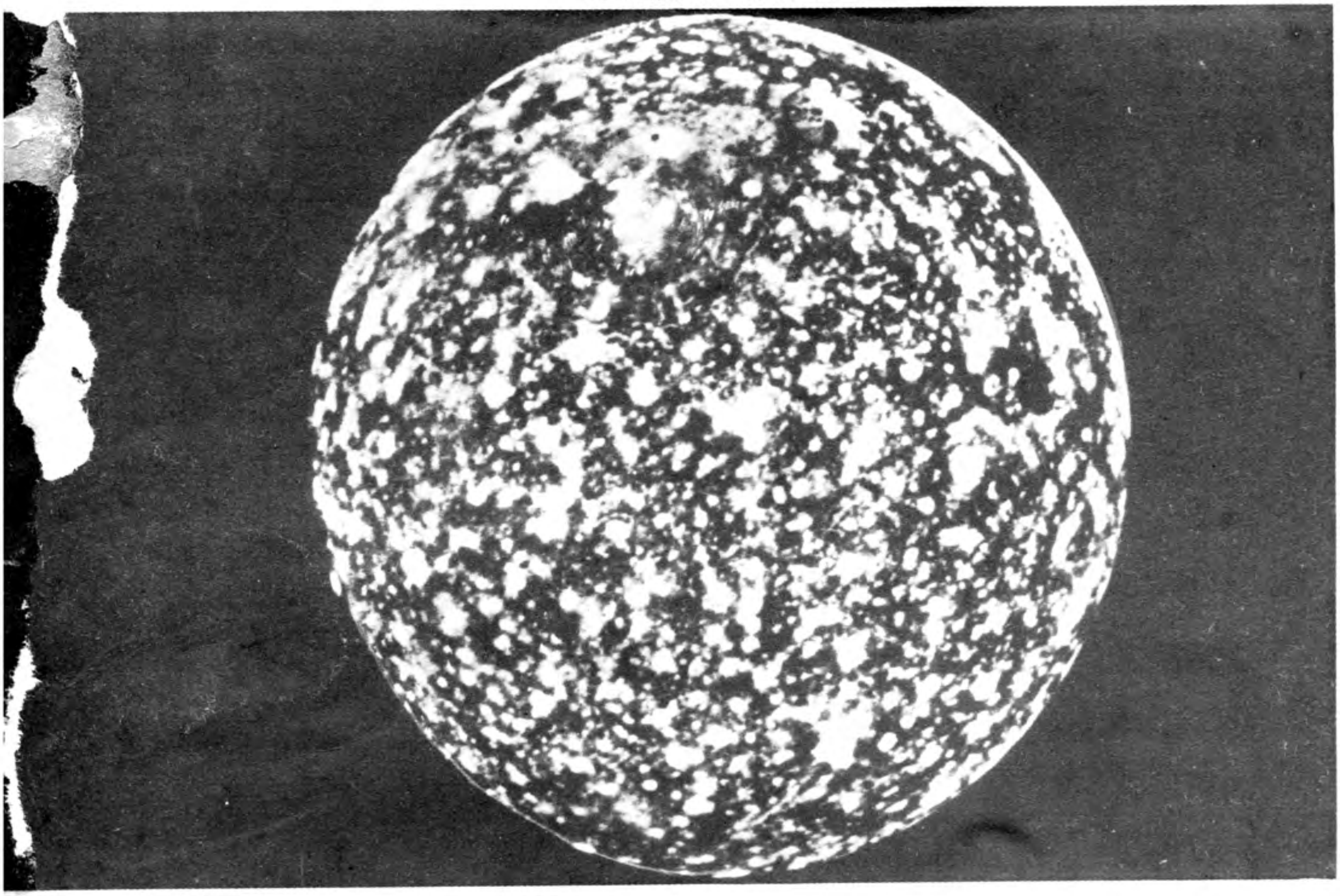

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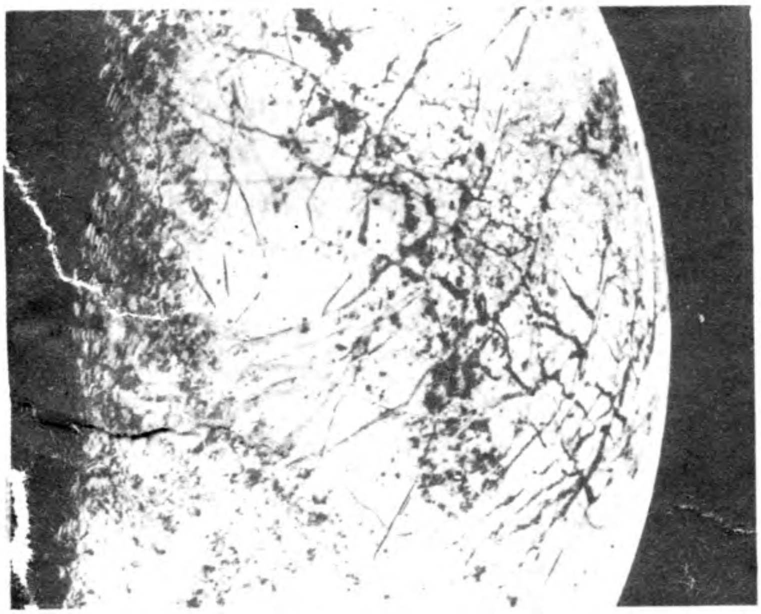

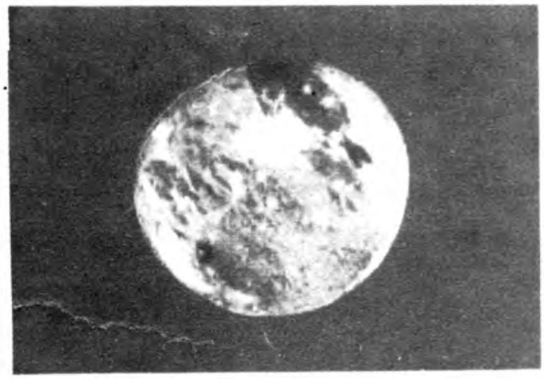

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Senior Members	£12.50	$28.00
Associate Fellows	£13.00	$29.00
Fellows	£13.50	$30.00

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To avoid the expense of collecting small balances, members who remit by Banker's Order are urged to ensure that the amounts transferred are the current rates.

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Payments may be transferred direct to our account by GIRO—either in the UK or abroad. Our account number is 53 330 4008.

International Money Orders from USA or Canada can only be cashed *if expressed to be payable in sterling.*(Money Orders from those countries expressed in dollars cannot be cashed abroad).

Fellows, Associate Fellows, Senior Members and Members who are 65 years and over on 1 January 1980 may claim a reduction of £1.00 ($2.00) from their annual subscriptions.

CHANGES IN MEMBERSHIP GRADES

Members who wish to upgrade their membership status when renewing for 1980 are reminded of the following:

(a) Transfer to Senior Member can be made by any person who has been a member for not less than five years.

(b) Qualifications needed for transfer to Associate Fellow takes into account long-standing association with the Society. New regulations specify that a person who has been a member for more than 10 years shall be eligible for transfer to Associate Fellow.

Remittances may be sent now to:–

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Over the past four years the Society's subscription rates have remained unchanged but have been gradually eroded by inflation so that their effective value is now barely half of that when they were originally set.

Nearly 1,000 members pay annually by Banker's Order so it is essential that the right sums are credited on 1 January next.

If you pay by Banker's Order, **please write to your bank manager now** to have the amount altered for next year. It is unnecessary to write to the Society for an amended form.

NEW SOCIETY PUBLICATION

HIGH ROAD TO THE MOON

An outstanding new publication, ready January 1980,* containing a large number of the visionary drawings and illustrations of the Late R. A. Smith and recording many of the Society's original ideas and discussions on Lunar exploration.

These pictures depicted ideas on orbital rockets, space probes, ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used again and again in books of the time: others have not been published before.

Now, Bob Parkinson – a members of the Council – has brought these pictures together with a commentary which tells how the pioneers imagined things would be – and how they were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the R. A. Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

R. A. Smith, a former President of the Society, died in 1959. He had been one of the pioneers of the Society and left behind him a collection of nearly 150 paintings and drawings which recorded one of the most visionary periods in its history. .

This book will be a MUST for all interested in space. For many reasons the number of copies printed will have to be limited.

To avoid disappointment later secure your copy NOW, with an advance order.

120 pp. Containing about 150 illustrations. Large (A4) size.

Order your advance copy from the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Pre-publucation price including postage and packing £6.00 ($15.00)

* *We are doing all we can to get this out by Christmas.*

A SPECIALISED SPACE LIBRARY

The Council seeks help from all members, both in the U.K. and overseas, who would like to help us to build up a collection of Technical Reports, specialised books and reference material on space research and technology, astronomy, and closely-related items such as space law, exobiology, etc. Donations of books, reports, photographs, films, recordings, paintings, models—in fact, any similar space-related publications or small artifacts, especially those likely to be of lasting value and which might form the basis for building up an Archive Collection, would be welcomed.

In view of the need to keep room available for later growth, collections of periodicals, popular books on astronomy or space, books not specifically related to our interests, or general books in foreign languages, cannot be accepted. Since we need to build up a "balanced" collection, members wishing to donate items are asked, in the first instance, to send details to the Executive Secretary, who is responsible for co-ordinating this part of the Society's Development Programme.

Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

CONTENTS

COVER

CALLISTO, EUROPA AND GANYMEDE. These magnificent photographs of three of Jupiter's Galilean moons were taken by Voyager 2 during its close encounter with the giant planet last summer. *Top,* Callisto from a distance of 1,100,000 km on 7 July. This black and white image has been enhanced to reveal maximum detail including a ring structure in the upper part of the picture. Callisto's surface seems to be a mixture of ice and rock dating back to the final stage of planetary accretion when it was pock-marked by a torrential bombardment of meteoroids. Young craters show up as bright spots, probably because they expose fresh ice and frost. *Bottom left,* Europa from a distance of 241,000 km on 9 July. The complex patterns on the surface suggest that the icy surface has fractured, and that the cracks filled with dark material from below. *Right,* Ganymede from a distance of 6 million km on 2 July. Again, ice appears to have fractured on the surface but the effect is different. Pieces of the crust have moved relative to each other since the Voyager 1 encounter.

NASA

SPACEFLIGHT

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MILESTONES

July

16 Controllers at NASA's Ames Research Center, Mountain View, California, fire two thrusters of Pioneer 11 to tilt the spin axis by 1.2 deg. (The antenna, aligned with the spin axis, is usually kept pointing toward Earth within half a degree to maintain the maximum communications data rate). The attitude change allows researchers to begin making measurements with the UV photometer, which searches for hydrogen, helium and other properties on Saturn, its rings and moons.

20 NASA celebrates 10th anniversary of first manned landing on the Moon achieved by crew of Apollo 11 (see page 443).

23 Space Shuttle Orbiter 'Enterprise' is returned to Vehicle Assembly Building by the crawler-transporter after completing compatibility checks with LC 39A at Kennedy Space Center.

26 Soviets reveal that a radio-telescope with an erectable 'umbrella' antenna of 10 metres (32 ft) diameter was deployed from the Salyut 6 space station on 18 July. The instrument – the KPT-10 – delivered by the Progress 9 automatic cargo craft, was assembled by the cosmonauts and checked out in the 'intermediate chamber' of the space station before release and erection of the antenna. However, it appears that part of the antenna was caught up on a projection of the space station. Progress 7, which also delivered fuel and air to Salyut 6, used its engine to propel the station into a higher orbit. It was then undocked and on-board TV camera allowed ground controllers to observe and control the movement of the radio-telescope and the erection of its antenna. The instrument will be used in conjunction with the new 70 metre (229.6 ft) ground-based radio telescope of the long-range space communications centre in the Crimea.

26 ESA Council Meeting approves first phase of Ariane development intended to increase injection of 1,700 kg mass into geostationary transfer orbit to 2,350 kg.

30 Jet Propulsion Laboratory selects TRW Systems Division for negotiation of a contract to design, build and test one of two spacecraft to explore the Sun's polar region during the 1980's. Contract is worth approximately $80 million. *(The spacecraft is one of two which will make up the International Solar Polar Mission. The other will be provided by the European Space Agency. The two spacecraft differ in size and appearance, and carry complementary (but no identical) science instruments. They will fly 'mirror image' orbits after the Jupiter encounter and then will cross over and under the poles of the Sun. Ed.).*

August

1 NASA announces that it will begin accepting applications for Space Shuttle astronauts on a annual basis. The period for submitting applications this year extends from 1 October to 1 December. Successful applicants will be asked to report to the Johnson Space Center, Houston Texas, in mid-1980 for a one-year training and evaluation programme as astronaut candidates, after which pilot and mission specialist astronauts will be selected.

6 Reported that Indian Earth Resources satellite Bhaskara has encountered problem with its TV camera system which has failed to switch on. Meteorological data are being obtained from other experiments.

8 NASA announces that 32 proposals for investigations using data to be obtained from the Magnetic Field Satellite (Magsat) have been accepted. Nineteen of the proposals were from U.S. principal investigators and 13

[Continued overleaf

from foreign scientists including one from Dr. D. R. Barraclough, Institute of Geological Sciences, Edinburgh, UK. The project, managed by the NASA Goddard Space Flight Center, is designed to measure the near Earth magnetic field on a global basis. The Magsat spacecraft, to be launched into a Sun-synchronous orbit by a NASA Scout from the Air Force Western Test Range in October, will carry two types of magnetometers, a caesium vapour scalar magnetometer and a fluxgate vector magnetometer. To minimise errors caused by spacecraft magnetic fields, the sensors will be located at the end of an extendable boom about 20 ft (6 m) long.

8 Reported that Japan's National Aerospace Laboratory has developed small mercury-ion motor for satellite attitude control. First flight test may be in Japan's Series III Experimental Test Satellite (ETS) in 1982.

9 NASA reports that Viking Lander 2 has photographed a new layer of water frost on the Utopia Plains. In September 1977 the same spacecraft found frost on the surface during the Martian northern winter (i.e., one Martian year or about two Earth years ago). At that time frost collection was associated with a major dust storm that had obscured the planet's surface before and during that period. But no dust storms occurred on Mars this year, so there is uncertainty about the causes that trigger the appearance of frost. This much is believed: dust particles in the atmosphere pick up bits of solid water (ice). That combination is not heavy enough to settle on the ground. But carbon dioxide, which makes up 95 per cent of the Martian atmosphere, freezes and adheres to the particles and they become heavy enough to sink. Warmed by the Sun, the surface evaporates the CO_2 and returns it to the atmosphere, leaving behind the water and dust. The resulting frost layer may be only one-thousandth of an inch thick.

10 Space Shuttle Orbiter 'Enterprise' flies out from Cape Canaveral aboard Boeing 747 carrier *en route* for Rockwell International's plant in Palmdate, California. (Stops were made at Atlanta, St. Louis, Tulsa, Denver and Salt Lake City to allow personnel of various sub-contractors to see the craft at first hand). After landing at Dryden Flight Research Center on 15 August, it was taken by road to Palmdale where it will be cannibalised for some of its internal systems.

10 India fails to orbit 81 lb (36.7 kg) Rohini test-satellite with four-stage solid-propellant SLV-3 rocket from Sriharikota Island, north of Madras. In this first launch of the Indian designed and built launcher, the vehicle suffered a malfunction and descended into the Bay of Bengal nearly 500 km from the launch site after a flight of some 15 minutes.

12 Reported that NASA will not re-start cluster testing of the Space Shuttle Main Engines (SSMEs) at the National Space Technology Laboratories, Mississippi, until late October. The delay follows a "fatigue failure" in the main fuel valve of one engine during a planned 520 sec static test in July. Problem was traced to a stress concentration caused by a cut-out for the valve actuator which cracked the valve casing and placed large shear loads on bolts used to secure the valve cap, fracturing several of them. Valve casing will be modified to provide a more generous fillet around the cut-out. A temporary limit is being placed on the number of test firings each valve is allowed to complete.

15 Cosmonauts Vladimir Lyakhov and Valery Ryumin spacewalk from Salyut 6 for 1 hr 23 min for the double purpose of "disconnecting the KPT-10 radio-telescope antenna which had hooked itself to the outside of the aggregate compartment," and of collecting samples attached to the station's exterior. (The whole operation was performed first in a simulator at the mission control centre to discover the optimum procedure). The cosmonauts opened the hatch of the transition compartment at 17 hrs 16 min (Moscow time) and Ryumin used the handholds to move along the outside of Salyut 6 to the rear end. Lyakhov emerged from the transition compartment to help his colleague. According to *Novosti*, Ryumin first assessed the actual position of the antenna and then drew closer, unhooked it with pliers and pushed it away into open space. The cosmonauts then collected the panels with samples of various structural, optical, heat insulation and polymer materials and instruments for micro-meteor registration. Some of these had been in space since 29 September 1977 when Salyut 6 was put into orbit and the rest had been installed by cosmonauts Kovalyonok and Ivanchenkov during their EVA in July 1978. During their spacewalk – completed 20 minutes earlier than scheduled – the cosmonauts tested their full-pressure suits and systems, as well as "new tools and gadgets." Commenting on future missions, Alexei Leonov said that EVA would be connected with "various assembly work and new scientific experiments."

19 Cosmonauts Vladimir Lyakhov and Valery Ryumin in re-entry module of Soyuz 34 soft-land at 15 hrs 30 min (Moscow time) 170 km south-east of Dzhezkazgan after longest ever manned space flight lasting 175 days. Preliminary medical checks show that they "withstood their long flight well." After landing they were placed in reclining seats to avoid walking and standing; then transferred by helicopter to the Baikonur cosmodrome for detailed medical examination. During the flight, "the cosmonauts undertook a large volume of repair and maintenance, including work with the joint power unit of the station and replacement of some systems and scientific equipment." In addition to conducting visual observations and photography of the Earth's surface, they carried out more than 50 experiments, under conditions of micro-gravity, to obtain "monocrystals of semiconductor materials, metallic alloys and compounds...". The cosmonauts also made a number of experiments in applying metallic coatings under micro-gravity and space vacuum "by methods of evaporation and subsequent condensation." They also conducted a number of scientific experiments and tests, including deployment of the radio-telescope KRT-10 used to carry out a series of astrophysical and geophysical experiments.

21 U.S. Air Force awards contract for design, production and launch of two upper stage rocket

[Continued on page 473

THE ORIGINS OF THE U.S. SPACE SHUTTLE - 1

By Curtis Peebles

Prologue

The idea of adapting rockets to aircraft dates at least to the mid-19th century to the work of such pioneers as: Charles Golightly (England), Werner von Siemens (Germany), General Russell Thayer and Sumter B. Battey (USA), Nicholas Petersen (Mexico) and Nikolai I. Kibaltchitch (Russia). The concept attracted Charles A. Lindbergh to the work of an obscure Clark University Professor, Robert H. Goddard. Rockets would provide a source of power much greater than that of a conventional piston engine. With that power, greater altitudes and speeds could be reached and that thought led, inevitably, to travels beyond the atmosphere [1].

As Goddard was making his test flights (supported by the grants Lindbergh helped to arrange), in Germany other tests and plans were underway. One of these was detailed in Dr. Eugene Saenger's 1933 book *The Techniques of Rocket Flight*. He detailed a rocket-powered craft able to reach 1,600 mph (2,575 kph) at stratospheric altitudes. This developed into the antipodal bomber, a track-launched rocket plane. After launch, it would use atmospheric skip to extend its range to 14,600 miles (23,490 km). Launched from Germany it could bomb New York or other US industrial centres and recover in Japanese-held territory.

The antipodal bomber was studied extensively from 1936 to 1942 when the programme was cancelled [2]. In the years following the war, theoretical work on winged spacecraft continued, both in the US by Dr. Hsue-Shen Tsien and in England by the British Interplanetary Society.

In 1947, the rocket-powered X-1 made the first supersonic flight. Other more advanced research craft were under development: the Douglas D 558-II and Bell's advanced X-1 series and the X-2.

These would lead to the X-15; the greatest and most successful of the high speed research aircraft. It would bring aviation to the borderline between air and space.

The First Shuttle

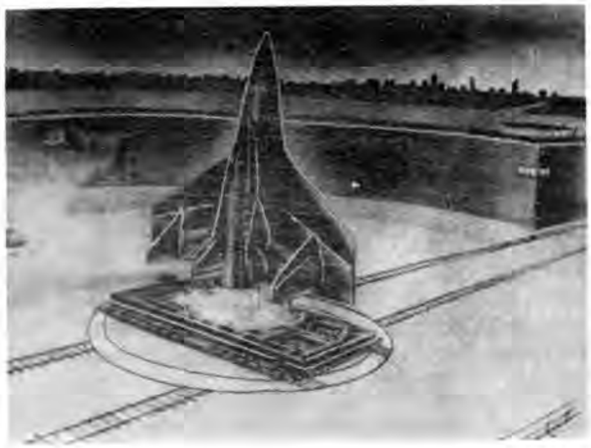
In 1951, under deepest secrecy, Bell Aircraft Company was conducting a study called Project Bomi. The vehicle had two stages, both manned; a large delta-winged lower stage booster carrying a small upper stage piggy-back.

Bomi was to be launched vertically from a turntable pad, the five engines of the lower stage and the three of the upper igniting together. All engines were fed from the lower-stage propellant tanks. 130 seconds into the flight, the two would separate; the lower stage would glide down to a runway landing, the upper stage continued on using its internal fuel. During the coast phase, one engine would continue to fire at a throttled-back level. This would prevent the on-set of zero-g. The maximum speed was 8,450 mph (5,239 kph). Maximum g-forces were calculated to be 3.5 g's; this coming when maximum speed was reached. The minimum loading, due to the continuously firing engine, was 1/4 g. The US could be crossed in 75 minutes at a peak altitude of 27.5 miles (44.35 km).

The programme's goals were multi-purpose. Bomi could function as a bomber or a passenger craft. The programme was under the direction of Dr. Walter Dornberger, former German Army General and Commander of Peenemunde and, at this time, a consultant to Bell [3].

The vehicle is sometimes referred to as the Dornberger Project. Much of the work was based on the antipodal bomber. Dr. Saenger was contacted by Dornberger to work on the project but refused preferring to remain in France.

Bell hoped that their success with the X-1 would result in an Air Force contract. Farsighted individuals in the Air Force saw the possibilities and in 1954, funding was made available to Bell. Bomi had become more than just a paper study. Events had been set in motion. Other later studies, by different companies, were made under a variety of code names: 118P (a high altitude reconnaissance craft) in 1956; then Brass Bell (a long range reconnaissance vehicle) and, finally, Project ROBO (Rocket Bomber).



The design that started it all: Bell Aircraft's Project Bomi.

Bell Aerospace Textron

What had begun as widely separated concepts had arrived laboriously as similar proposals for a boost-glide vehicle. During this same period, articles in *Collier's* magazine, by Dr. Wernher von Braun and others, brought the coming space age to a wider audience.

The National Advisory Committee for Aeronautics (NACA) had been studying the problems of ICBM warhead re-entry. From this work, came studies of manned satellites, ranging from ballistic vehicles to winged gliders. In 1954, a study was made comparing various configurations of manned vehicles for range, g forces, re-entry heating and booster requirements.

By the latter half of 1957, one of the authors, Dr. Alfred J. Eggers, Jr., was convinced of the advantages of the glider concept. He was concerned about the high g and heat loading of a purely ballistic capsule. But a winged glider, he knew, was too heavy for existing boosters so he developed the M-1 design; a flat topped, blunt cone shaped vehicle able to manoeuvre during re-entry and land like an aircraft. It was the first lifting body deriving its lift from its shape rather than its wings [4].

As the 50's neared their end, there was, as yet, no sign of how these advanced concepts could be translated into hardware. The Eisenhower Administration's attitude toward space ranged from disinterest to hostility. In response to the "scientists pressure group", the Vanguard programme was begun in 1955 but there had been no formal commitment for missions beyond the International Geophysical Year. The Air Force had received, for space research, $10 million but only for component development. System development was absolutely forbidden as was the use of the word "space" in any official statements. It was frivolous in the view of many Administration officials [5]. So conditions remained until a Friday night, 7:30 p.m., 4 October 1957.

The Dyna-Soar

On 14 October 1957, while the post-Sputnik crisis was still building, the Air Force and NACA representatives met to review the previous studies of boost-glide vehicles to follow the X-15. The studies made during the decade had shown the Air Force that there were potential missions for such a vehicle. Clearly, the Russians understood this, too.

For NACA, although it would play only a minor role, the boost-glide concept would provide flight data beyond the Mach 6 speed and brief entries into space by the X-15. Also, the boost-glide concept, an outgrowth of over 50 years of aviation technology, appeared to be the best way into space, at least on a routine basis. The experimental (and unproven) ballistic capsule was viewed with skepticism by many. This meeting was the start of the Dyna-Soar programme*.

In November 1957, the Air Force issued development directives for the programme and a development plan was approved. 1 January 1958, the Air Force issued a request for proposals and by March, seven companies had sent in proposals. Within the industry, the Bell Aircraft/Martin team was given the inside track to receive the contract. But the Bell design was overly complicated; it used a system of coolant tubes within the wing's leading edge. Boeing had found such efforts were not needed. The company's philosophy was to keep the design as simple and as cheap as possible.

Boeing wanted the project desparately; it had lost the B-70 contract and had passed up the Mercury programme because of the limited number of capsules. Dyna-Soar presented a chance to branch out into the space technology field. 23 March 1958, the contracts were narrowed to Boeing and Bell/Martin. Added studies and preliminary development work was undertaken. June of '59, at the Air Force request, Boeing submitted possible military missions for the vehicle. The studies included global surveillance and an orbital command post. The proposals and studies were evaluated until 9 November 1959 when the Boeing glider and the Martin booster were selected [6].

In December of '59, before the Air Force and Boeing could proceed with development, Assistant Secretary of the Air Force for Research and Development, Joseph V. Charyk, ordered Phase Alpha. This study was a virtual re-opening of the contractor competition. Phase Alpha's purpose was to verify the design and materials and to get in-put from a number of sources. North American Aviation proposed a modified two-seat X-15. Lockheed submitted a folding wing design. Avco proposed an inverted parachute and Goodyear's design was for an inflatable system. A definitive development programme was to be worked out [7].

Another purpose was to overcome years of skepticism within the Eisenhower Administration, and the Department of Defense, over the programme's feasibility [8]. Phase Alpha was completed on 25 April 1960. The documentation stood 13 ft (3.96 metres) high and made no changes in the Boeing design. DoD released funding and work began.

The Phase Alpha development programme called for three steps. The first and the only one approved, called for sub-orbital launching by a modified Martin Titan I. Entry speed was on the order of 18,000 to 19,000 feet per second (5,625 to 5,937 metres per second). The reason for the sub-orbital flights was because, at this time, there were no adequate orbital boosters available.

The first air drop from a B-52 was set for the fall of 1963. The first unmanned flight was to take place in early 1964 and the first manned flight in early '65. There would be parallel manned and unmanned flights to allow a faster speed build-up without so many intermediate steps. An important point, since only 10 or so flights were planned, after re-entry the gliders would land on runways on Grand Bahama Island, Mayaguana Island, Mayaguey, Puerto Rico, St. Lucia and Ascension Island. One early plan called for the construction of 11 gliders, three ground test vehicles, four unmanned and four manned [9]. In addition seven tests of sub-orbital models were to be made using the Scout booster beginning in June of 1962 [10]. Step 2 hoped to make orbital flights using either an improved Titan or Atlas. Step 3 called for a complete orbital weapon system using a Saturn launch vehicle.

The Dyna-Soar programme differed from previous research effort in that an operational system was expected to develop directly, not as a separate programme.

The Eisenhower Administration felt that the $800 million cost was too high for a purely experimental programme. Except for load capacity, the Dyna-Soar had to have operational performance and equipment. There was disagreement over this. Some in DoD wanted this requirement dropped in order to speed up development and simplify requirements. But the dropping of the weapons system requirement would, because of the high cost, make the programme vulnerable [11].

The Dyna-Soar Run Around

January 13 1961, the launch vehicle was changed to a Titan II. This gave a higher speed re-entry, 20,000 to 21,000 fps (6,097 to 6,402 mps) just under orbital velocity [12].

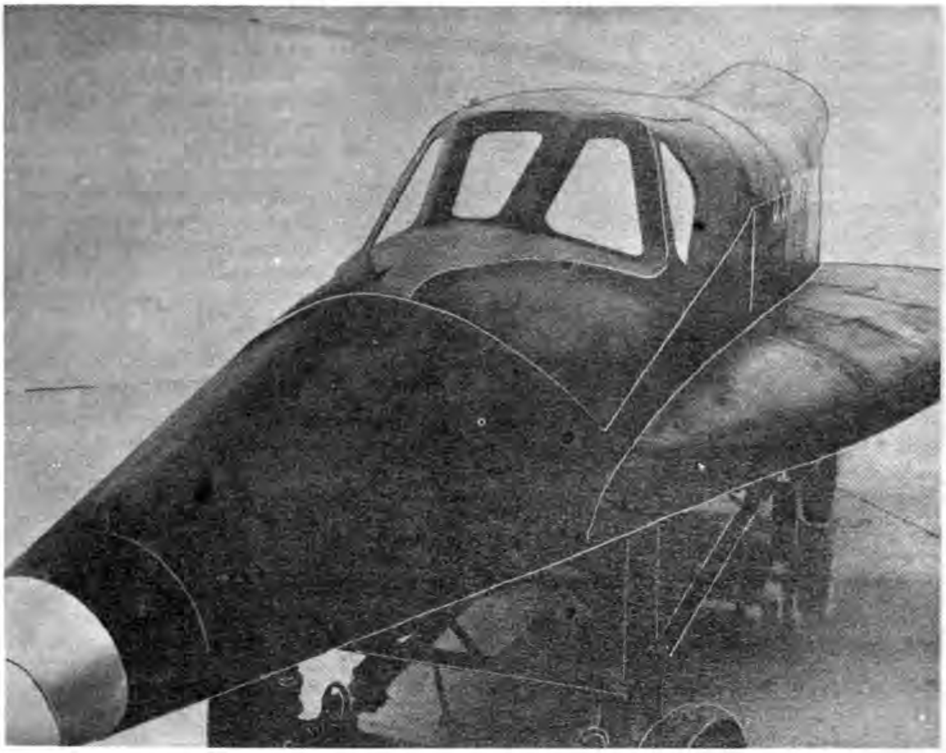
By the spring of 1961, most of the major structural and aerodynamic designs were set. Most of the 1,600 engineers on the project were working on sub-systems, hydraulics, electronics, controls and the like. But if the technical problems were being solved, the political ones were continuing. In mid-1961, Defense Secretary, Robert S. McNamara, ordered the Air Force to justify the Dyna-Soar on the grounds of an identifiable military mission [13].

The Air Force proposed such missions as orbital reconnaissance, rescue, satellite inspector, bomber and ferry vehicle. In the latter configuration, it could carry, in its equipment compartment, four men in 'cramped' conditions or half a ton of cargo; the study was not well received. That summer, Boeing proposed project Streamline. The elimination of the sub-orbital flights; going directly into orbit. The orbital flights would gain data on re-entry, and as a result up to twice as much information would be acquired per flight [14].

The Streamline study examined possible orbital launch vehicles. They included: various Titan II's, with differing solid fuel strap-on configurations, a Titan II with a Saturn S-IV upper stage, a Titan II with a new high energy upper stage and a new 4-stage all solid fuel design. It recommended, however, Saturn I as this offered the most payload and would be ready sooner. As a possible option, a smaller Dyna-Soar was proposed; with one-half the wing area, it would ease launch constraints but at increased risks. To justify going directly to orbital flight, it was proposed the Dyna-Soar test components for such programmes as Nimbus, Advent, Courier, the orbital observatory programme (OAO, OGO, OSO) as well as to support Apollo development. One artist's concept showed what appeared to be an open payload bay door.

Military missions were not overlooked. One possibility was a quick reaction reconnaissance mission, launched

* *Dyna-Soar is a contraction of Dynamic Soaring.*



Close-up of the Dyna-Soar mock-up showing clearly the expansion gaps between the panels. The actual vehicle was to be constructed of such heat resistant materials as Rene 41, molybdenum and columbium. The Dyna-Soar was to be re-usable but it was uncertain how much skin treatment/ replacement would be necessary. The jettisonable wind screen cover has been removed in this photo.

Boeing

in the Gemini programme. The Gemini spacecraft had a wider military potential, such as rendezvous, tests of reconnaissance film and such equipment as the astronaut manoeuvring unit. It could handle the Dyna-Soar's follow-on missions without modification. It was, also, to fly sooner by 18 months. The Air Force hoped this would develop into its own separate Gemini programme. March 11, 1963, the X-20 was cut back to a research and development role, a decision to cancel being put off to make yet another study of any possible advanced missions.

Work on the first flight vehicle had begun and roll-out was set for 1964; modifications on the B-52C drop plane were also underway. All through 1963, there was debate within DoD as how the Dyna-Soar was to fit in. In September, the Air Force transferred Dyna-Soar from the Aeronautical Systems Division to the Space Systems Division. It was seen as a unifying effort to gain support and stave off cancellation. On 10 December 1963, what everybody had been expecting occurred – the X-20 project was cancelled.

Secretary of Defense, McNamara, ordered that the remaining funding be transferred to the Air Force Manned Orbiting Laboratory. To replace Dyna-Soar, a broader-based study of re-entry was to be made. Work on the Dyna-Soar prototype was stopped. The parts completed were scrapped. Boeing set up a hiring hall for the 5,000 employees laid off. Of the X-20 astronauts, Albert Crews, Jr., was later picked to be a MOL astronaut. In 1969, after the MOL was cancelled, Crews joined NASA in a non-flight role.

At the time of the cancellation, Milton O. Thompson was involved as a pilot in both the X-15 and the M2-F1 lifting body programme.

The only one of the six to actually fly into space was Captain William Knight, doing so in 1967 as an X-15 pilot. That same year, he set a world speed record of M.6.72. The others: Major Henry Gordon, Major James Wood and Major Russell Rogers resumed their normal Air Force careers. Unhappily, Major Rogers was killed on 13 September 1967 in an F-105 explosion over Okinawa [22].

The Reasons Why

The story of the Dyna-Soar was one of delay, re-orientation and official hostility. Its situation could be traced to that of the late '50's and early '60's. In the wake of the Sputnik trauma, the U.S. space effort went from a minor effort to a crash catchup programme. There was great uncertainty about how the new U.S. space programme was to develop. Civilian and military space goals were still to be sorted out and priorities set. It was not until the mid-60's that this had been completed.

The Dyna-Soar was caught between these circumstances; the policies of both the Eisenhower and Kennedy Administrations and the normal technical problems inherent in such advanced programmes. There had been weight gain. The airframe was too limited in size and capacity for useful work. As a result the Dyna-Soar was delayed to the point of obsolescence; it would merely put one man up for one orbit contemporary with the first Apollo-ballistic capsules. Nevertheless, the project left behind a legacy of data; a starting point for a completely new round of effort towards spacecraft re-usability which would come later.

Lifting Bodies

While the Air Force worked on the Dyna-Soar, NASA had been continuing wind tunnel research on lifting bodies at both Ames and Langley. They had even been considered for use as the Apollo command module. By the early '60's, considerable data had been developed on a wide variety of shapes. It was decided to build a manned lifting body. Called the M2-F1 for Manned 2-Flight 1, it was built of plywood around a welded tube frame.

The vehicle was fitted with an ejector seat and a small solid fuel rocket. The rocket could be used to extend the landing glide in the event of a too rapid descent. Because of its experimental nature, the M2-F1 underwent wind tunnel tests in the Ames 40 x 80 ft (12.5 x 25 metres) wind tunnel. February 1963, the tests were completed and the

The M2-F1 is towed aloft for a glide flight. The vehicle checked out the low-speed characteristics of lifting bodies.

NASA

M2-F1 was delivered to the NASA Flight Test Center at Edwards Air Force Base, California [23].

M2-F1 Flight Tests

As the Dyna-Soar programme was being cut back, car tow taxi tests were beginning with the M2-F1. Milton O. Thompson was the pilot; the tests using a Pontiac tow car were chiefly to test the control system and for pilot familiarisation. The tests were a pioneering step and, like other journeys of exploration, the steps could be hard. On 1 March 1963, the first attempt to fly the M2-F1 was made. As it was pulled across the lake bed, it bounced from side to side, struggling aloft; it could barely stay airborne for a second.

These first tests had uncovered problems not apparent from the wind tunnel data. Analysis of film taken during the tests traced the problem to the car wake turbulence; the wheels hitting the ground and pilot over-controlling, a problem aggravated by the rather simple control system. The NASA test crew looked for a solution. After much trial and error, a re-arrangement of the control system and the removal of the centre fin appeared to correct the situation. It was not until 5 April 1963 that the M2-F1 finally became airborne [24].

During the car tow test, four firings of the landing rockets were made, two with the M2-F1 in motion. No adverse effects were noted. The maximum speed reached during the approximately 60 car tow flights was 120 mph (194.5 kph). With the basic stability problems now overcome, the next step was air tows by a C-47. Before they could begin, however, a series of tests, using a conventional sailplane, were run to determine the best tow position. The C-47 wake could easily throw the M2-F1 out of control. The final tow position was 150 ft (45.7 metres) above and 1,000 ft (304 metres) behind the C-47.

On 16 August 1963, the first C-47 tow flight was made. A typical flight began with a take-off from Rogers Dry Lake. The C-47, with the M2-F1 in tow, began a circular climb, skirting the edge of the dry lake bed to insure a safe landing if the tow line broke. Release came at an altitude ranging from 10,000 to 13,000 ft (3,048 to 3,962 metres).

After separation, the pilot pulled full left rudder and stick to avoid the C-47 wake. During the glide back, test manoeuvres were made including sideslips, rudder fixed aileron rolls and aileron and rudder pulses. The M2-F1 proved to have marginal stability. The tendency to dutch roll (a rapid side to side rocking of the aircraft) was stronger than expected. It was, also, very susceptible to gusts. The air tow flights were postponed if surface winds exceeded 5 knots (2.5 metres per second). Later this was relaxed to 10 to 15 knots (5.14 to 7.22 metres a second) with light turbulence. Considering the limited manoeuvres the operational vehicle would have to undertake, control was considered adequate. The last 2,000 ft (609.6 metres) of the glide were used for landing flare. Pilot experience also was a key factor. On some days, two flights could be made. In approximately 90 test flights, the M2-F1 had proven the basic feasibility of the lifting body concept during the critical landing phase. Higher speeds and altitudes were yet to come [25].

ASSET

The ASSET programme (Aerothermodynamic/Elastic Structural Systems Environment Tests) was begun in 1960 to support the Dyna-Soar programme. Like that programme, it went through its own changes. The Scout launch vehicle was replaced by a Thor and only six launches were planned. The small gliders embodied the design and structural features of the full scale Dyna-Soar. They had the same general shape and were constructed of the same basic materials. The gliders carried, as instrumentation, five thermocouples, 35 pressure transducers, 6 deflection sensors and 4 'G' metres. After separation they were controlled by hydrogen-perioxide jets and to affect recovery, a parachute, flotation bag and beacon were carried on some flights. Models were 68.7 in long (1.79 metres) and had a wing span of 58.9 in (1.53 metres). Depending on the vehicle, weights varied between 1,100 and 1,200 lb (500 to 545.5 kg). Prime contractor was McDonnell Aircraft Company.

In September of 1963, a Thor, one of those deployed in England and since re-conditioned, was being prepared at the Cape, and on 18 September 1963, the first glider was launched towards Ascenion Island. The Thor flew a "roller coaster" trajectory, peaking at 203,377 ft (62,005 metres), then pitching downward. Separation came at 195,000 ft (59,451 metres). The maximum velocity was 16,093 fps (4,906 mps). Telemetry radioed back, as it glided, confirmed that re-entry was successful; the refractory materials had turned back the frictional heat. The parachute opened and aircraft, in the recovery zone, sighted it descending, but, the flotation bag broke on splashdown and the glider sank [26].

This flight was the Dyna-Soar's last hurrah. Three months later, the programme was cancelled. In the place of the Dyna-Soar, McNamara announced that the ASSET programme would be expanded. The re-entry profiles were to be more severe and additional flights were scheduled.

In early 1964, soon after the cancellation decision, preliminary work was begun on this extension of ASSET. This was START (Spacecraft Technology and Re-entry Program), the over-all name of a considerably more involved programme than ASSET. START would involve both sub-orbital re-entry tests and low speed manned research aircraft. There were hopes that it would lead to manned orbital systems. Vehicles under study were lifting bodies. At the same time, NASA was making the decision to continue the M2-F1 programme with vehicles capable of higher speeds and altitudes.

It was against this background that the second ASSET launch took place on 24 March 1964. The launch vehicle was a Thor/Delta. The target speed was 18,000 fps (5,487 mps). After first stage burn-out, the second stage fired momentarily, shut-down, re-ignited, shut-down again, then continuing over several cycles before shutting down for the last time. As the booster fell out of control, the glider separated. The guidance system attempted to recover from a 60° bank. The glider had almost been brought back on course when the five-second delay on the self-destruct pack-

age ran out and it was destroyed. Some data had been achieved during its brief flight. The fragments of the glider and launch vehicle fell into the sea 475 to 500 miles (766 to 806.5 km) downrange near San Salvador Island [27].

The third rocket was modified to prevent a reoccurrence and was scheduled to repeat the ill-fated flight profile of its predecessor. After four hours of holds, the third ASSET was launched on 22 July 1964 to achieve a maximum speed of 18,000 fps (5,487 mps). The mission tested a vapour deposited disilicaide coating, originally intended for the Dyna-Soar. The underside was made up of a variety of molybdenum panels. It, also, carried a liquid-cooled double-walled panel and a tungsten nose cap. The only problem during the flight was a malfunction in the control jets. Nevertheless, the glider was fished out of the Atlantic by a navy vessel at 11:11 EST, 12 hours after launch and a post-flight examination indicated it could be flown again [28].

Model number four – the first of the environmental test vehicles (AEV) – was launched late in the evening of 27 October 1964, with the object of studying elastic and structural affects. The three earlier missions were aero-therodynamic structural vehicles (ASV) which were heat shield tests. The glider carried an 8 x 10 in (20.3 x 25.4 cm) corrugated flutter panel of columbium on the vertical ramp which was periodically flexed. The single-staged Thor propelled the glider to a release altitude of 166,000 ft (50,609 metres) and 13,000 fps (3,963 mps). Telemetry was relayed during the 900+ seconds flight. But as its speed dropped below Mach 2, the glider became unstable and impacted 900 miles (1,451.6 km) from the Cape. No recovery was planned [29].

ASSET number five, the second of the two AEV's, was launched by a Thor on 8 December 1964. The data flow was good throughout the flight, the maximum altitude achieved being 174,504 ft (53,202 metres) and speed 13,000 fps (3,963 mps). The glider impacted 740 miles (1,193.6 km) down range. Again no recovery was attempted [30].

At 9:31 EST on 23 February 1965, after two holds, the sixth and last ASSET roared out of the Cape. The two-stage Thor Delta propelled it on the longest and fastest flight yet – 2,700 miles (4,354.8 km) down range and 19,000 fps (5,945 mps). It carried twelve samples of refractory material including damaged samples and had 2,000 spots of heat sensitive paint in ten colours. These spots, on both the inside and outside of the vehicle, changed colour as heated so that a thermal profile could be made. The flight was successful.

Telemetry was recorded throughout the flight but except for a brief radar trace and sporadic beacon signals, nothing more was seen of the glider. It was believed that on splash-down, the flotation bag broke free and it sank. This denied the necessary visual examination of the paint and material samples [31].

The five successful flights had gathered data on the flight environment at a wide range of speeds and angles of attack. The ASSET programme studied structural response, system and sub-system performance, varied testing techniques and corrulated in-flight data with theoretical knowledge and ground tests. Above all, it proved that a winged vehicle could be built to withstand the demands of re-entry [32].

The fourth ASSET on the nose of its Thor booster. This was the first of the environmental test vehicles (AEV). It returned data on flutter and oscillatory pressure at hypersonic speeds.

U.S. Air Force

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THE 'INTERCOSMOS' COSMONAUTS

By Wilhelm Hempel*

Introduction

Cosmonauts from Czechoslovakia, Poland and the German Democratic Republic orbited the Earth together with Soviet colleagues on board the Salyut 6 orbital laboratory. They were looking at the Earth from a distance of 350 km. Their successors are now training at the Yuri Gagarin Cosmonaut Training Centre near Moscow. They are from Bulgaria, Rumania, Hungary, Mongolia, Cuba and Vietnam. Their training includes work in a centrifuge, getting to know the Soyuz and Salyut spacecraft by means of a simulator, and theoretical and practical preparation for their special research tasks.

Origin of Joint Flights

Joint manned flights into space were decided upon by the Intercosmos Council in Moscow in autumn 1976 as a new stage of steadily growing cooperation. Every member country of the organisation has the same vote and seat in the Council regardless of individual contributions.

This decision was justified by the level of cooperation already existing at that time; the Intercosmos partners of the Soviet Union had qualified themselves for such flights in a logical development procedure. At the beginning they had studied the basic elements of the new technology with satellites of the Cosmos series—also called "sputniks of friendship". This stage was rounded off by individual contributions to the first series of Intercosmos satellites.

By autumn 1976 the GDR had developed about 80 onboard and 50 ground instruments for the joint space research projects of Comecon, including highly efficient instruments from the Institute for Electronics, the Centre for Scientific Apparatus Production, the nationally-owned Carl Zeiss factory at Jena, the Robotron Computer works and other institutions.

With the change from smaller instruments to apparatus of increasing sophistication, systems like the MFK-6 multi-spectrum camera and the high-quality SI-1 Infrared-Fourier-Spectrometer, the demands on the organisers of the cooperative programme increased both nationally and internationally. In the early period of cooperation a single institute or even a small group of scientists and technologists were able to contribute to a space experiment; but today this involves the cooperation of a whole number of institutes and industrial enterprises. Planning has become more complicated and joint projects require steady coordination and synchronisation.

Economic Benefits

The economic benefits of space research are becoming ever more apparent. This is shown especially by the study of Earth resources from outer space. That is also why the datelines of the state plan periods and those of the "Intercosmos" programme have been brought into correspondence.

As a result the first space flights of cosmonauts from socialist countries have ushered in a new period of socialist space cooperation. Already the first few flights have shown that this international cooperation is not a matter of prestige or a demonstration of togetherness but an objective necessity. The working programmes of each of the cosmonauts included both multilateral and national tasks based on the traditional research requirements and economic interests of the various "Intercosmos" member countries or their individual scientific institutions. Major Miroslaw

Soyuz 31 cosmonauts Sigmund Jähn (GDR) and Valery Bykovsky (USSR) are checked out in their spacesuits.

Panorama DDR/Zentralbild

Hermaszewski of Poland, for example, made crystals of the rare mercury-cadmium-telluride under weightlessness thus contributing to the study of infrared semiconductor materials. These investigations have been carried out for more than 10 years by the Institute of Physics of the Polish Academy of Sciences.

The growing extent of space research makes a further division of labour, specialisation and long-term joint planning indispensable. The special situation in the individual countries—geographical location, economic structure and other factors—are taken into consideration. In the interests of deep-sea fishing and navigation Poland concentrates on maritime research, including marine biology and space navigation aids. Mongolia gives priority to obtaining exact maps of its territory and to the prospecting for its mineral resources, few of which have been explored. Cuban experts need reliable meteorological aids for long-range weather forecasts of the Western hemisphere.

Much more research is to be done by cosmonauts from the socialist countries in the coming years. GDR cosmonauts will continue to participate.

* *Presidium Member, GDR Astronautical Society*

THE ORIGINS OF THE U.S. SPACE SHUTTLE

Continued from page 441]

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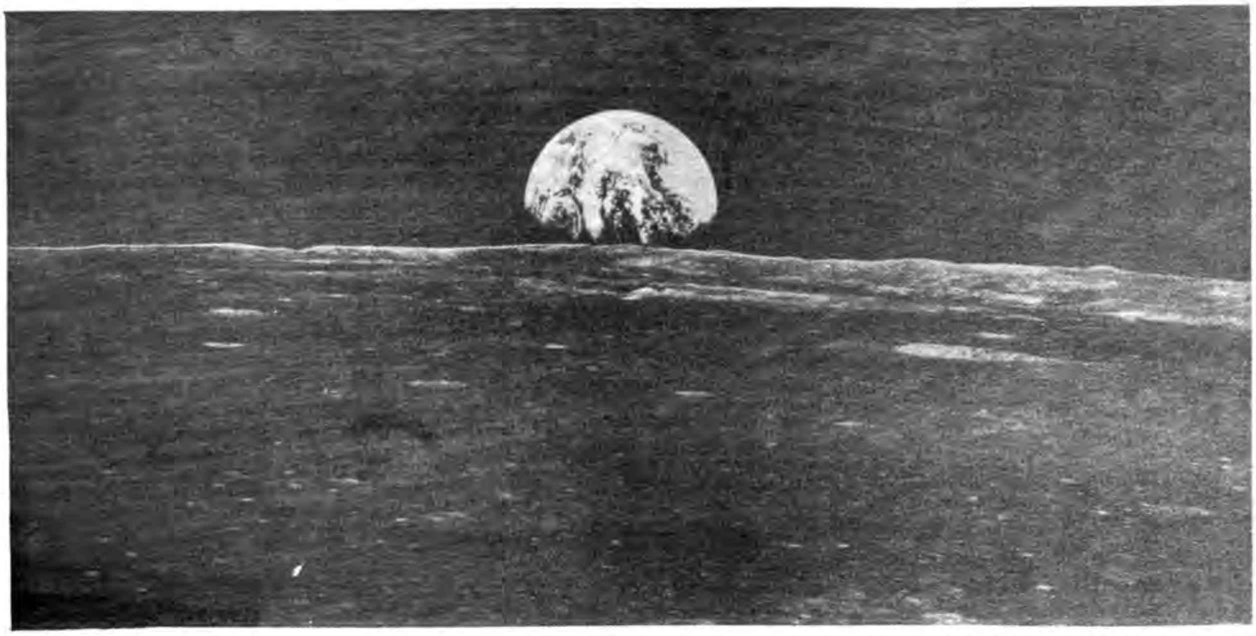
[To be continued

THE LAST DAY OF THE OLD WORLD

Ten Years After Apollo 11

By Jesco von Puttkamer *



Earth rise over the Moon. The spectacular view that greeted the Apollo 11 astronauts as they came from behind the Moon after the lunar orbit insertion burn.

NASA

Too late for inclusion in our July issue commemorating the 10th anniversary of Man's arrival on the Moon, we received this article from a distinguished programme manager of the National Aeronautics and Space Administration who "saw it all happen". We were sure that readers would welcome this further postscript to the magnificent story of Apollo 11. Ed.

A Toast to History

On the third Friday in July, in my study, a bottle of champagne will be uncorked. At 4.17 pm EDT, properly seconded by my family, I will raise my glass in the direction of my five-foot model of a Saturn V. And my cheers will quietly go out to you, Neil, Buzz and Mike, and to you, Wernher, and to all those others who made it happen. And I know I'm going to feel proud. For on 20 July, 1979, it has been ten years since Earthlings for the first time landed on another world, when the "Eagle" of Apollo 11 came screaming down to the Moon's surface.

The landing had been hair-raising.

Sitting there in the Houston Mission Control Center in Texas, in the Huntsville Operations Support Center in Alabama, in the monitor rooms of the other NASA manned space flight centers, our eyes were riveted to the display screens where the drama unfolded. The lunar module had come around the Moon's eastside into sight of Earth, already on a descending course. At 4.05 pm, with twelve minutes to go, the lander's rocket engine fired up. Direction and magnitude of its braking force were controlled automatically, by computer. A downward-looking radar provided altitude and velocity data.

* *Advanced Programs, Office of Space Transportation Systems, NASA.*

Suddenly Neil Armstrong's voice barks, "Program alarm! Its a 1202!"

At five minutes and sixteen seconds after ignition, the computer is crazily flashing yellow signals: "1202 . . . 1202 . . ." *Alarm! Alarm!*

What a thoroughly scary moment, so starkly remembered! Because these were "executive alarms", signalling an imminent computer breakdown due to computational overload. They were interfering with an early assessment of the landing approach by the crew. But they didn't faze the flight controllers who were monitoring the descent guidance as reported by Doppler tracking from several Earth stations. In case of problems with onboard systems, those were to be used as a "voting source". And so, flight controller Stephen Bales made his judgment and gave the word to Neil Armstrong and Edwin Aldrin: "You are go! Ignore the computer and proceed with the landing!"

Later it turned out that the "Eagle" computer, organized to handle a number of different functions simultaneously by time-sharing, had been asked during the landing phase to handle one task too many—and it had been an unnecessary function: the processing of some essentially meaningless signals from the electronics steering the rendezvous-radar antenna on the brow of the "Eagle" which was tracking the command ship "Columbia".

As the computer continued flashing its alarms, now being ignored, a new menace began compounding the cliffhanger, building up—for some of us—to a state of gut-wrenching suspense.

Man at the helm

The view out of his window had made it increasingly clear to Armstrong that the automatic pilot was taking them right into hazard: its course led to a boulder field surrounding a large, sharp-rimmed crater. And so, two minutes and

Astronaut Edwin E. Aldrin, Jr., descends the ladder of the Lunar Module 'Eagle' as he prepares to walk on the Moon. Picture by astronaut Neil A. Armstrong.

NASA

eighteen seconds before touchdown, at 600 feet height, Neil keyed program P-66 into the computer, took over control and continued flight manually for about 1,100 feet beyond the bad landing area. With the Commander cooly searching for a safe place to alight, seconds were ticking by and the "Eagle" was running out of fuel fast...

When the "Eagle" finally landed, a shout of relief went up. With only about 700 pounds of propellants left, no more than 23 seconds of flight time were remaining before only immediate mission abort and return to orbit could have saved the crew. And we took our first breath after dieing innumerable deaths.

Sure I'm biased ... ! But in looking back to that long, long night of 20 July I find that words will never adequately describe that tremendous surge of thoughts, feelings, emotions washing over us. The safe landing of Apollo 11 climaxed an incredible eight years of the lives of all those many people fortunate enough to have been part of it. Afterwards, those lives never were the same again. For how can you top that peak of individual professional achievement and satisfaction and pride? Something had been done to our very souls.

The public reaction

Outside our closed environment, the world struggled to comprehend the event. Monday, 21 July, was turned into "Moonday", and President Nixon declared a national "day of participation". San Francisco's Mayor Alioto urged citizens to fly the flag day and night during the Moon Mission. Band leader Duke Ellington composed a special song, "Moon Maiden", and made his singing debut broadcasting it. At Chicago's O'Hare Airport, an elderly lady awaiting a flight simply stood up and sang "America the Beautiful" at the top of her voice. In Peru, a mother named her baby, born during the flight, after Neil Armstrong. Radio Warsaw said, "Let them come back happily! Their defeat would be the defeat of all mankind". A Bogota newspaper headlined, "The Future Has Commenced!", while a West-German paper bannered, "Boys, Come Back Safely!"

Throughout the preceding 102 hours, punctuated by these responses from all over the world, the mission had been smooth and on schedule, ever since the tremendous liftoff of the mighty Saturn V on 16 July. *"Estupendo!"* a Spanish TV announcer had shouted. A Soviet professor in Moscow telephoned, "Attaboy, Americans!" and Arthur C. Clarke had said on CBS television, "I haven't cried or prayed for 20 years, but I did both today. It was the perfect last day of the old world".

How was it done?

For those of us in the Apollo team who had worked on the Saturn V itself, the liftoff had had a special meaning. The new tools and techniques of systems engineering and program management, first introduced in the Air Force and in such undertakings as the 5½-year Manhattan Project but modified uniquely for the 8-year Apollo Program, had taught us engineers how to pool our knowledge, skills and motivation in large-scale teams. Even so, very few of us were completely familiar with the entire 364-feet tall monster machine, and no one was at ease when that mammoth took off on five roaring engines as large as 2½-ton trucks. Over all, Apollo 11 had eight million working parts, 91 rocket engines and, fully loaded, the weight of a Naval destroyer. Little wonder, then, that we had built into the Saturn all kinds of safeguards, margins and redundancies hedging against malfunctions and providing "abort modes" to the crew, just in case ...

Of course, there is a better way for you to get an appreciation of Apollo's magnitude than looking at spectacular statistics. Just go out in your backyard some night, look up at the Moon–*really* look up and try to imagine how you would do it if you had been asked to do it, back in that Camelot Spring of 1961 with its oddly desperate enthusiasms.

Yes, on that morning of 16 July, when launch vehicle AS-507 was fired out of Launch Complex 39A, we were in awe. We had "go fever", champing at the bit to have this bird, the big one, get off on time. Earlier that day, Dr von Braun, in charge of Saturn development, had helicoptered over from the Holiday Inn in Cocoa Beach where he and his family stayed in Suite 192. We knew, after eight years of intense work, that we had good hardware, but–as Wernher said in the firing room after lift-off–"you also know there's a lot of room for mistakes, and this is the sixth one in a row".

All together, fifteen Saturn V's were built.* For us engineers, it had meant a task of often baffling complexity that could not tolerate failure. A unique challenge of our professional skills, of human curiosity and pioneering spirit, a new frontier of creative realization of idealistic thought models–the dream goal of every engineer in the world. For

Astronaut's foot and footprint on the lunar soil.

NASA

industry, it meant big business: Billions of dollars flowing in thousands of contracts and subcontracts with ten-thousands of US industrial firms in almost all States and huge payrolls for close to 400,000 people—as many as were engaged in manufacturing autos and trucks. By pushing our industries to the limit, Apollo spawned new ideas, new management methods, new techniques, new quality control, new developments that were breaking new ground all along the way and strengthened the nation's industrial foundations: Pratt & Whitney, RCA, Rockwell, IBM, Boeing, Honeywell, McDonnell Douglas, Bell, Grumman, and countless more. For the nation, Apollo gave birth to a new sociology involving government, industry and universities in close-knit, massed teamwork, made possible by the new tools of project management—which some of us liked to describe as merely "the art of doing what you said you would".

What killed off Apollo?

What was it that killed off Apollo after those unforgettable summer days ten years ago?

In that very same summer of 1969, President Nixon recommended the largest cut in the NASA budget of any year since the agency's inception. The President's Space Task Force under Vice President Spiro Agnew had recommended a continuation of Apollo lunar missions, along with development of a space shuttle, a permanent space station, and a manned expedition to Mars before the year 2000. Apollo originally was conceived by John F Kennedy, Lyndon Johnson and their advisers in response to the Soviet Union's successes with Sputnik 1 and Yuri Gagarin's orbital flight, in order to re-establish American pre-eminence in science and exploration and, thus, its prestige in the world. But much had happened in the eight years since: the deaths of John Kennedy, Robert Kennedy and Martin Luther King, the black people's outcries at Birmingham, Selma, Watts and wherever there were ghettos, the violence at the 1968 Democratic Convention in Chicago, the drug subculture and the Manson murders, and the nation's growing reactions to the Vietnam involvement. Simply, the nation's mood had changed, as reflected by a Congress increasingly preoccupied with problems on Earth that generated little enthusiasm for bold new ventures in space.

And so, right after Apollo 11, the "rules of the game" were changed on us: from a rationale of political prudence, prestige and pre-eminence to one of economic merit. Our activities in space now had to meet the pragmatic test of costs versus benefits. Since the lunar landing programme had never been designed to these new standards, it had to fail the test. Thus, one year after the first Moon landing, because of reduced funding, NASA had to cancel Apollo 20, 19 and 18 and substantially to revise and curtail its plans for the Apollo Applications Program, later to be called Skylab.

Well, we faced the music: Our old dream of putting men on Mars receded into the limbo of a far future, out of our professional lifetimes.

At first our disappointment was immense. There were shouts of "Not fair!" Ensconced in our Shangri-La of engineering, we felt deep hurt when the momentum was slowed down. Somehow it seemed senseless that ten years of our lives had been dedicated to what now was labelled by many a wasteful exercise of technological bravado. Then, slowly, we came down from our "high", waking up to reality. After all, Apollo originally had been initiated as a kind of psychotherapy for the nation. As such, it had been hugely successful. Now, having done the job, it was time for us to ensure a more solid future for manned space flight by bringing it into the realm of social relevance, people needs and economic realism. Above all, we realized clearly and sharply: the future of the space programme depends on the quality of the programme NASA can provide the public and the Congress.

Apollo 11 crew: *Left to right,* Neil A. Armstrong, commander; Michael Collins, command module pilot, and Edwin E. Aldrin lunar module pilot. *NASA*

The legacy

Today, that's what it's all about. The promise of Apollo is still with us: new dimensions for our material and spiritual wellbeing. For, as the great astronomer George Ellery Hale said,

Let those who complain that too much money is being spent on abstract knowledge while people are starving remember this: The alternative to knowledge is savagery. Their very existence as stowaways on the voyage of civilization is owing to advances in science which permit some to live without doing their share of the work. Let them be tolerant, then, lest by encumbering the useful ones they destroy the thing which keeps them alive.

And when civil rights leaders Rev. Ralph Abernathy and Hosea Williams led an old mule-drawn wagon and 150 poor blacks to the launch of Apollo 11, NASA's Tom Paine told them:

I want you to hitch your wagon to our rocket and tell the people the NASA programme is an example of what this country can do. I personally, and the members of the space programme, feel that the space programme is a programme for all America, and we hope it will make a resolution for Americans to band together to fight the problems you are talking about.

Today, that rocket is the Space Shuttle. It alone is the key to fulfil what Apollo has promised. The new programme of its economic use and of industrializing space that is being designed around it, is in direct response to the down-to-earth needs and demands of people everywhere.

Ten years after Apollo 11, the Apollo expeditions are only shining memories, but their legacy is all around us. Because of them, we know that the space programme is inevitable and that it will exist as long as mankind exists. Because of them, we knew how to design and launch the new transportation system, the Shuttle, which will allow us to do the first step into a future alive with new frontiers and unlimited growth. And because of them the Shuttle's first flight into space will herald the First Day of the New World.

Our plans may have entered limbo. But the vision is still there.

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*Two Saturn V's are left over today, both on public display.

SCOUT - NASA'S SMALL SATELLITE LAUNCHER

By Andrew Wilson

Introduction

With 37 consecutive successes to its credit, the Scout has become the world's most successful launch vehicle and last summer saw its 100th launch, from Wallops Flight Centre in Virginia.

Over the years it has become the space workhorse for the smaller payloads, just as Delta has been for the medium-mass payloads. It will continue to be used after the introduction of the Shuttle, although in much reduced numbers.

Background

Although the first launch of the Scout did not take place until 1960, the history of the vehicle can be traced back to a research probe programme of NACA (National Advisory Committee for Aeronautics) in 1945. By mid-1957 the then Langley Field was studying a rocket to extend the capabilities of solid-fuel research, and it was this concept that evolved into a four-stage launcher capable of carrying a 130 lb payload into a 300 mile circular orbit.

The need for such a launcher was clear because at that time there was no cheap, quickly-produced rocket for the smaller payloads. It also marked a switchover from the space programme being handled by the three services in rivalry to a single developer, the newly-formed NASA, although the motors used in the initial versions originated in military programmes–first stage from the Navy Polaris, second stage from the Army Sergeant and the third and fourth stages from the Navy Vanguard.

NASA awarded the development contracts for the motors in 1958 and Chance Vought won the vehicle contract against competition from twelve other companies in early 1959. By that time the rocket had been named 'Scout' in the spirit of the name 'Explorer', the series of small satellites with which Scout was destined to become closely associated.

The aim of the project was to produce a relatively inexpensive, reliable, solid-fuel rocket which could be used in standard configurations for NASA, DoD and foreign payloads. As we will see, the reliability requirement of 90% took a long time and considerable effort to achieve.

This article looks at the NASA Scout programme although the Air Force did develop their own version–Blue Scout–in 1959. Details of the Blue Scout are to be found in reference [1].

The Scout Project Office at NASA's Langley Research Centre (LaRC) will be referred to throughout the article because it is they who translate the programme requirements established by NASA HQ in Washington, D.C. into the technical and contractor requirements for a launch. In other words, the SPO looks after almost every aspect, technical and managerial, of the rocket and it is information from some of their documents which provided the basis for this paper.

Apart from its high reliability, the Scout is distinguished by being the only all-solid major NASA launch vehicle and the only major NASA rocket launched from three sites (Wallops, Vandenberg and San Marco). Its career has been divided into different 'phases' designed to reflect its status at any particular stage in its life and at present it is still in Phase VII:

Phase I : development
II : prototype
III : recertification
IV : management
V : incentive procurement
VI : award fee procurement
VII: continuing programme

Phase I was the basic development stage which resulted in ten launches before Phase II was declared to have begun. All of the Phases will be described in detail later.

Basic Vehicle Description

The majority of Scouts have been four stage vehicles which are basically four motors divided by four transition sections and topped by a payload and its shroud (Fig. 1).

The vehicle stands on the base section 'A', consisting primarily of four aerodynamic fins and four jet vanes for vehicle control. During first stage boost the jet vanes provide the majority of control forces while the movable tips of the fins provide all of the control moments when the first stage motor has burned out and the vehicle is coasting prior to first/second stage separation.

Sections 'B' and 'C', on the other hand, provide attitude control during the boost and coast phases of stages 2 and 3, respectively, by employing a system of hydrogen peroxide (H_2O_2) jets which operate in 'on' or 'off' modes. In transition section 'B' four 500 lb thrust motors provide control in pitch and yaw while four 40 lb thrust motors give control in roll. The reduced thrusts of the motors carried by transition section 'C' reflects the smaller workload after stage 2 has separated: four 60 lbf and two 2 lbf motors give control in pitch and yaw, with four 14 lbf motors controlling the vehicle in roll.

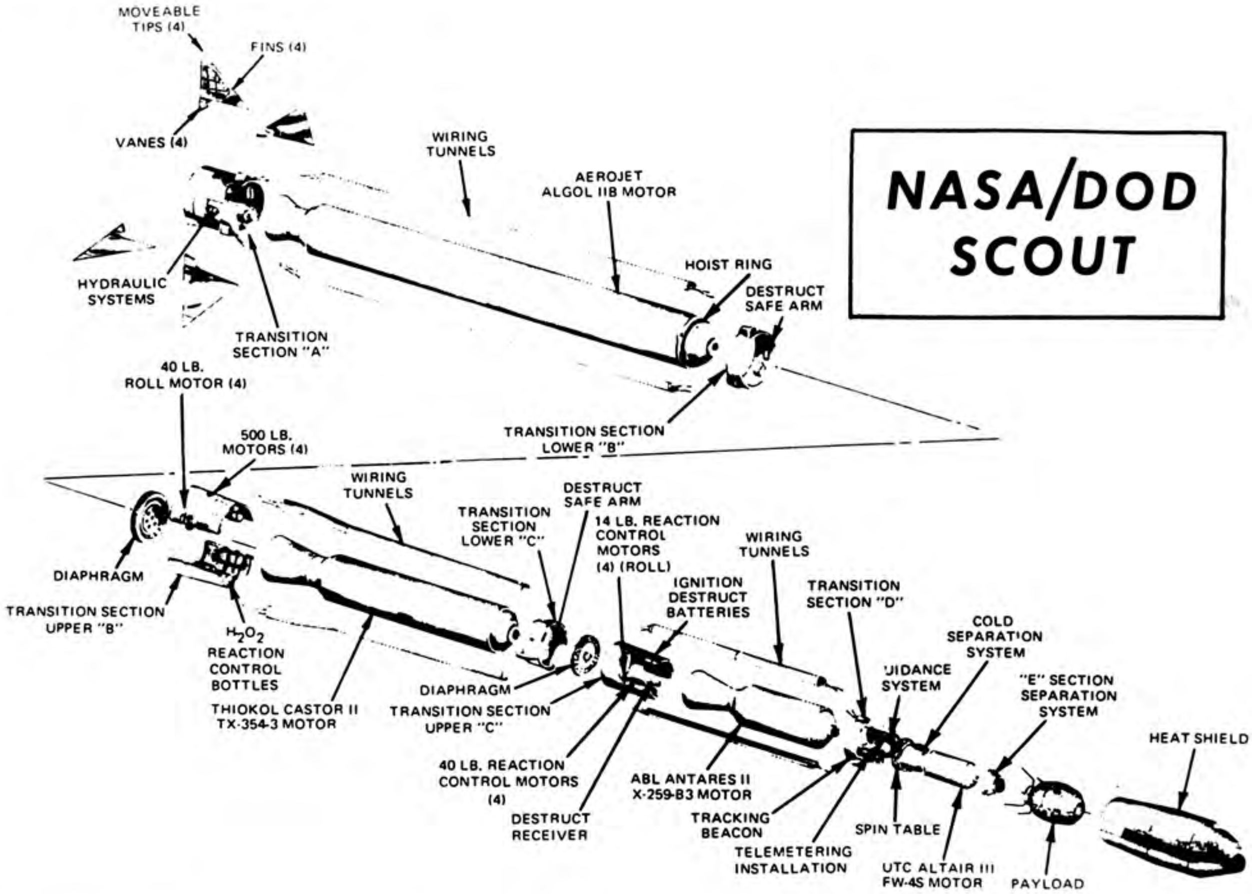
Transition section 'D' carries the spin table and motors which avoid the use of rocket motors for guidance for the upper stages by spinning up the fourth stage and its payload before third stage separation so that proper orientation is maintained by using the third stage attitude motors. The guidance package is also carried in transition section 'D'.

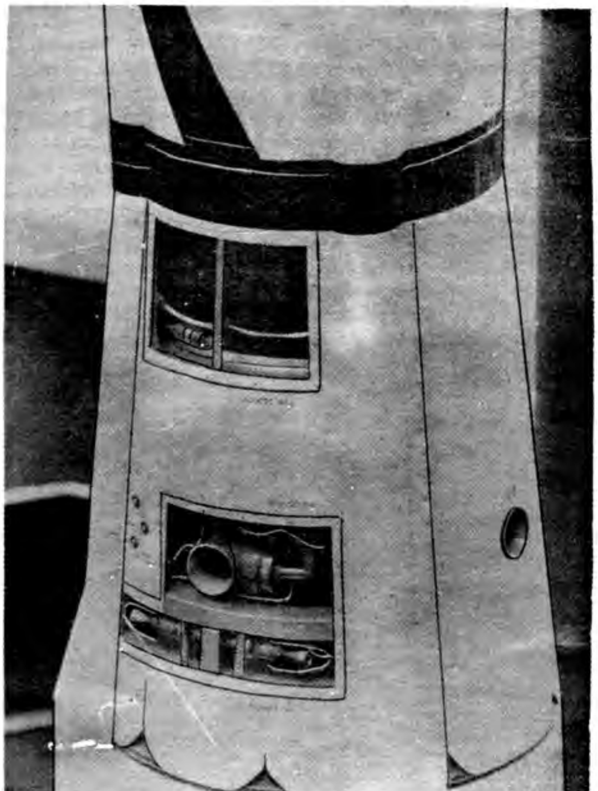
Heatshield

The heatshield covers the payload, fourth stage and upper 'D' section in order to carry out its main function of providing environmental protection for the payload during ascent through the atmosphere when external temperatures may reach well over 500°C. In addition, the payload can be warmed or cooled while it is still on the pad by purging the heatshield with air from the payload environmental system of the launch tower.

Eleven types of shield have been flown over the Scout's history with the general trend towards larger diameters and lengths. Table 1 lists the shield types with their flight records up to the end of Phase V (Scout-177). In general, a shield is identified by its diameter and the station of its tip. For example, type G is described as a '34-25' because it has a diameter of 34 inches and its tip reaches to station -25.

From Phase VI, only the G (34-25), J (34-40 and K (42-45) types have been used, with the latter reserved for the largest payloads. The 42 inch was first flown on S-144-CR with the 286 lb PAET re-entry payload. These shields are constructed form a fibreglass laminate and honeycombe material formed into half shells with a nose cap attached to the shell next to the launch tower. The 34 inch shields use stainless steel nosecaps while the 42 inch carry aluminium caps covered inside with cork. Latches along the separation plane and a clamp around the base hold the shield in position until separation takes place, typically some 130 seconds after launch. Internal springs force the halves apart until aerodynamic drag can whip them away from the vehicle prior to third stage ignition. Hatches of various sizes are possible in the heatshield, depending on what the payload requires and structural integrity allows.

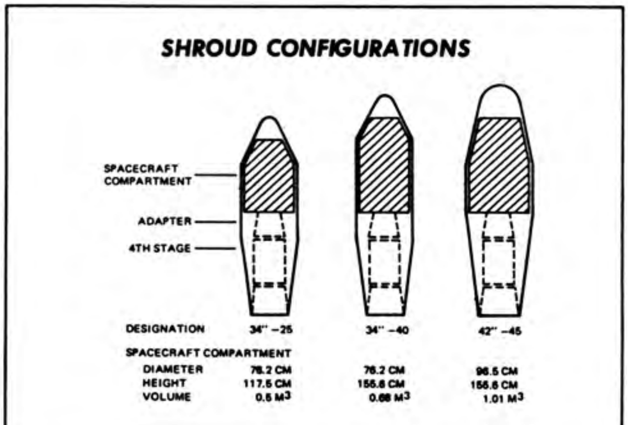




Above, Fig. 1a. Exploded view of Scout B.

Left, Fig. 1b. Two of the access doors have been replaced by clear panels in this view of transition section 'B' of the Scout on display in the National Air and Space Museum, Washington, D.C. The lower panel shows two of the small roll motors and one of the 500 lbf pitch and yaw motors (a second can be seen to the right).

Below, Fig. 1c. Three heatshield designs are in general use by Scout today.



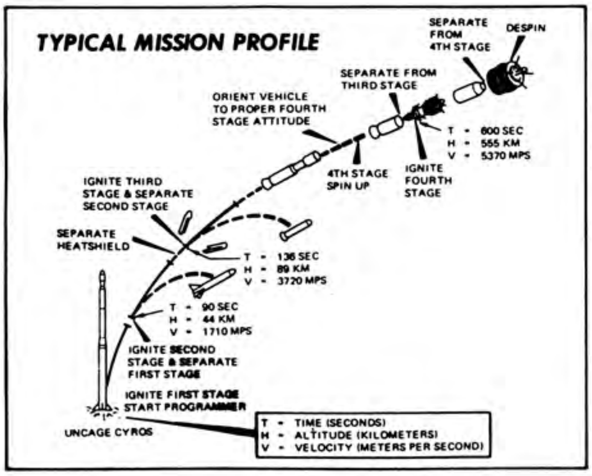


Fig. 2. Typical mission profile.

Payload Mount

The size and weight of a payload determines the type of adapter necessary for its attachment to the final stage. At present there are four designs of payload mount available for a four stage configuration but, in general, they are very similar. The main difference is the increase in weight–all are conical semi-monocoque magnesium structures–to accommodate payload weight increases. Since some missions do not require payload separation the 7.6 lb separation system is added only when necessary. With a five stage vehicle, a 'G' section is used to support the payload on top of the BE-3A fifth stage. In this case, a transition section called the 'F' section is also needed to separate the fourth and fifth stages.

Since the upper stages are spin stabilised, static and dynamic balancing is necessary with everything in flight configuration. For this reason balancing is usually carried out at the launch site in the spin balance facility where the configuration is built up part by part with temporary ballasts being added as required. When the staging is completed all the temporary ballasts are combined into two masses, one on the 'E' (four stage Scout) or 'G' (five stage Scout) section and the other close to the spin assembly near the base of the fourth stage.

With the heatshield in place, the standard four-stage Scout is typically some 76 ft in length with a launch weight of 48,600 lb.

Ignition of the first stage of the Scout is achieved by a direct electrical impulse provided by a blockhouse command while ignition of the other stages is controlled by the guidance programme timer carried in the transition 'D' section atop the third stage.

The table below gives a typical example of the main sequence of events in a standard Scout orbital launch (Fig. 2):

Sec	
T -0.13	stage 1 ignition
T 0.00	liftoff
T +82.82	stage 1 burnout
T +90.28	stage 2 ignition, stage 2 attitude control takes over, stage 1 separation
T +129.51	stage 2 burnout
T +132.81	heatshield separation
T +134.51	stage 3 ignition, stage 3 attitude control takes over, stage 2 separation
T +170.80	stage 3 burnout
T +585.09	upper stages spin up for stabilisation
T +586.59	stage 3 separation
T +591.44	stage 4 ignition
T +624.13	stage 4 burnout

The profile of re-entry and probe missions and the actual mechanics of staging will be discussed in later sections.

Scout terminology

The Scout has appeared in many versions, some of which have never flown, and unfortunately for the layman the terminology has not always been clear-cut. Table 2 lists the launches in chronological order and Table 3 sorts out the vehicles according to their designations and gives their constituent motors. Fig 3 illustrates the rocket's evolution and Fig 4 shows how the orbital capabilities of the vehicle have improved since the first version in 1960.

There are clearly two systems at work in Scout nomenclature. The first, the X system, was adopted for the first launches and gave way to the newer system during Phase IV when the first standard Scout was used.

There were a few rules followed in the X system:

- When a fifth stage was included, the letter 'A' was added. The X-3 thus became the X-3A after the NOTS-17 fifth stage was added. Only five 'A' flights were carried out.

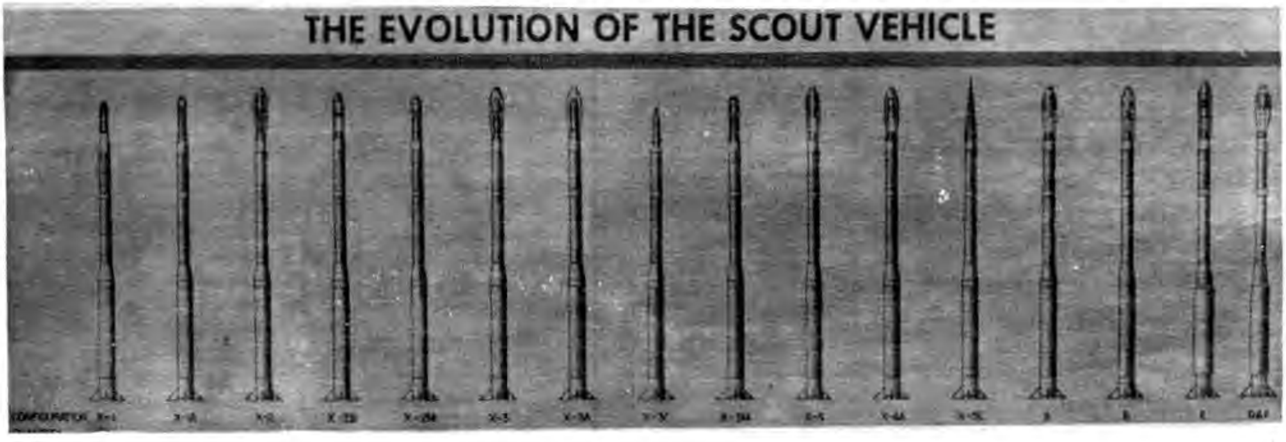


Fig. 3. Scout configurations.

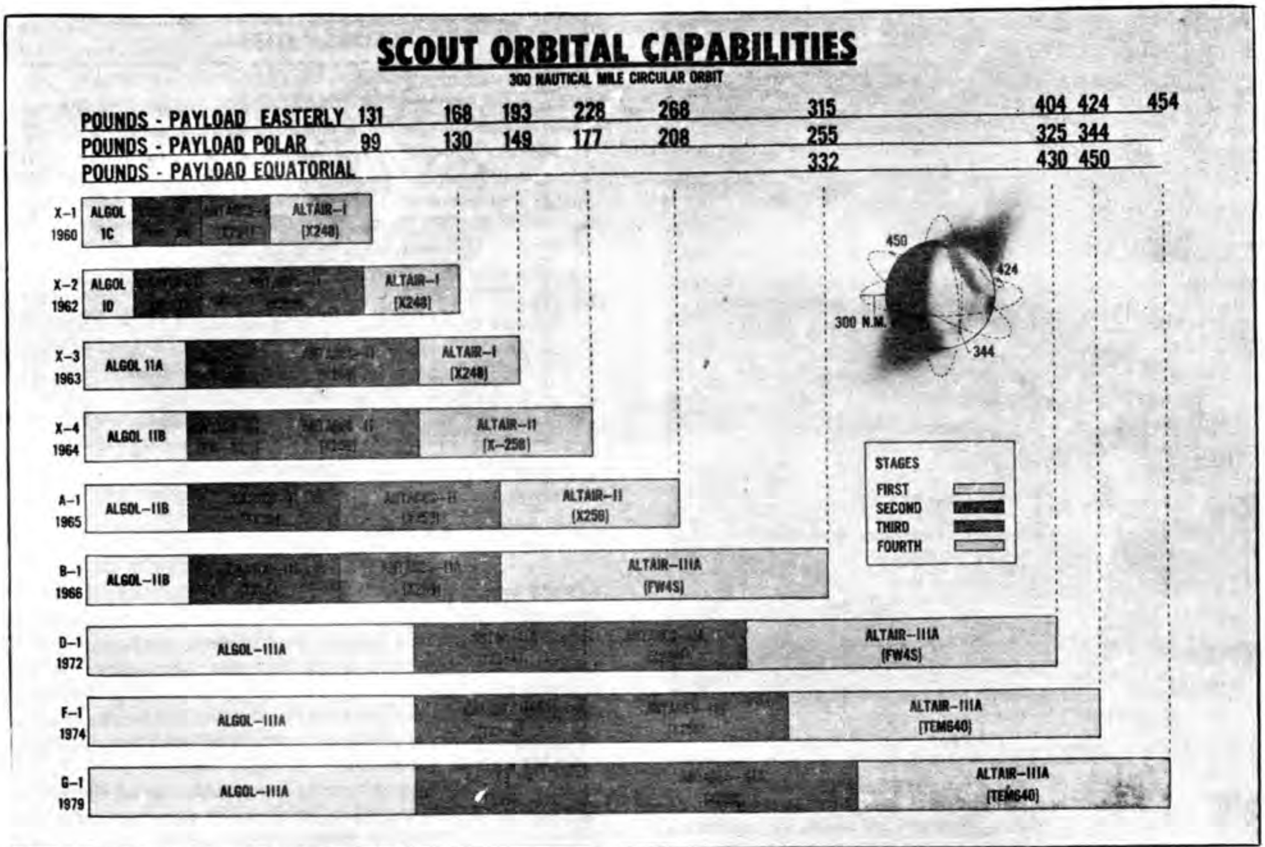


Fig. 4. Scout vehicle growth. Vehicles denoted A-1 and B-1 have been re-classified 'A' and 'B' respectively.

- When the Altair fourth stage gave way to the M2 fourth stage, the letter 'M' was added, resulting in the X-2M and X-3M versions.

- Two X variants carried no fourth stage at all and had 'C's added to their designations.

With the introduction of the second system during Phase IV things became a little clearer* but even this has suffered an alteration in mid-system; note from table 3 that there were A, A1, B and B1 versions which had their own distinctive configurations. Now, however, there is only one version per letter so that the only 'D' type is the 'D1'. Similarly for E, F and G but A and B should be regarded as early exceptions to this convention. A possible H-1 version is planned.

Note, also, that all of the stages provided by the SPO are named after stars.

Scout C

Four solar probes were planned for launch in 1972 and 1973 by a new Scout variant, the 'C'. The BE-3 motor was to have been incorporated as a fifth stage velocity package to allow 35 lb payloads to be placed into 0.5 AU heliocentric orbits. When 'Sunblazer' was cancelled by the Office of Science and Applications, the Scout C was left unused and its capability for high-velocity missions was bettered when the Scout E was introduced in 1974. Thus a Scout version is left with no launches to its credit and even Scout E has had only one launch.

* *Atlas and Delta use a similar system.*

Scout X

The first Scout launch came on 18 April, 1960 but it is not usually included in launch totals because it carried two dummy stages and was not therefore a complete vehicle. It is included in Table 3 but is omitted elsewhere.

Phase I

The first major contracts of Phase I, and of Scout in general, were the agreements covering all four motors, beginning in May, 1958 with Thiokol (stage 2: Castor), followed by November, 1958 with Aerojet General (stage 1: Algol) and December, 1958 with the Allageny Ballistics Laboratory (stage 3: X-254; stage 4: X-248). It was not until April, 1959 that NASA contract NAS1-249 with a value of $1,823,780 was signed with LTV for the first four airframes (confusingly, the basic airframe is known as the 'vehicle' within the industry), following a contract the previous February for guidance and control equipment with Minneapolis-Honeywell. NAS1-249 also called on LTV to provide support equipment, launch and work tower and, later, instrumentation, support assistance, services and materials.

The Scout began its developmental launches well enough with two probe missions flying successfully from Wallops Island in 1960, the second reaching a maximum altitude of 3,100 miles. Since these were test launches the vehicles were given 'ST' (Scout Test) designations. The first attempt at an orbital launch, with ST-3 in December, 1960, proved to be a failure. The Algol IA first stage of the Scout X-1 burned well but the Castor IA second stage failed to ignite, the reason being a 'procedural deficiency in ignition system checkout'. The payload on this occasion was a 12 ft-diametre balloon called Beacon designed for LaRC-based air

Fig. 5. The first successful orbital launch by any all-solid fuel rocket was by ST-4 in February 1961 when the 12 ft diameter balloon Explorer 9 was put into orbit. The black bands denote the length of the second stage motor while the helical band allows the orientation of the vehicle to be optically determined from the ground during flight. Contrast the Mk I launch tower with the Mk II version shown on page 458.

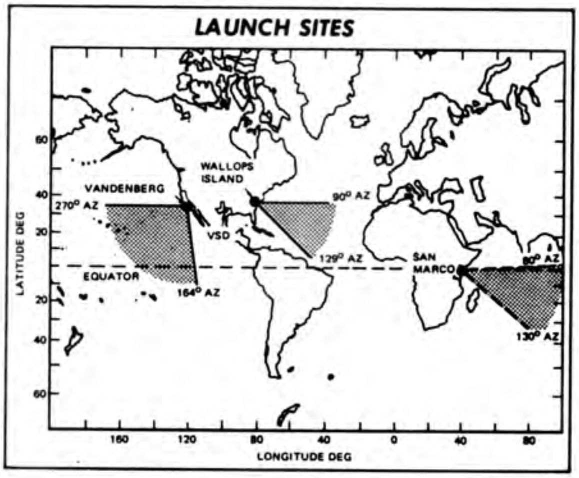


Fig. 6. Scout launch sites.

density experiments and it proved to be the first of a long series of balloon satellites involving LaRC and the Scout. Indeed, ST-4 orbited Beacon 2's successor, Explorer 9, in February, 1961, becoming the first all-solid rocket to orbit a payload and the first rocket to reach orbit from Wallops (Fig. 5). Explorer 9 remained in orbit until 9 April, 1964 by which time its successor, Explorer 19, had been successfully launched by a Scout.

ST-4 was the first vehicle to use a motor from the second batch of contracts signed in April, 1960 which included the purchase of two further second stage motors. The other new motor was used by ST-7.

While the vehicles from the first LTV contract were in the middle of their launch programme, contract NAS1-900 of August, 1960 established LTV as NASA Scout prime

		1	2	3	4	5	6	7	8	9	
		X-1 ST-1	X-1 ST-2	X-1● ST-3	X-1 ST-4	X-1● ST-5	X-1● ST-6	X-1 ST-7	X-1A ST-8	X-2 ST-9	phase I
1	X-2 111●	X-2M 112●	X-2M 117	X-3A 114●	X-3 115	X-3 118	X-3M 126	X-3 119●	X-2M 121●	X-3 116	phase II
2	X-3 120	X-4 113	X-3A 110●	X-2B 132●	X-4 122R	X-3 127R	X-4 125R	X-4● 128R	X-4 124R	X-4A 129R	phase III
3	X-4 134R	X-3C 130R	X-4 123RR	X-4 133R	X-4 135R	X-4 137R	X-4 136R	B 131R	X-4 138R	X-4 139R	
4	A 140C	A 142C	X-4A 141C	A 143C	B 145C	A 146C	B 147C	B 148C	A 149C	B 150C	phase IV
5	B● 151C	A 154C	B 153C	A 155C	A 156C	B● 152C	A 157C	B 159C	B 158C	A 162C	
6	B 160C	X-5C 164C	B 161C	B 165C	B 168C	B 167C	B 172C	B 169C	A 176C	B 171C	phase V
7	B 174C	B 175C	B 173C	B 144CR	B 177C	B-1 180C	B 166C	B 163C	B-1 183C	D-1 184C	phase VI
8	B-1 182C	D-1 170CR	D-1 185C	D-1 181C	A-1 178C	D-1 190C	D-1 188C	E-1 191C	D-1 186C	D-1 189C	
9	B-1 187C	F-1 194C	D-1 195C	F-1● 196C	B-1 179CR	D-1 193C	D-1 197C	D-1 200C	D-1 201C	D-1 202C	phase VII

Fig. 7. Scout vehicle/type history.

● = Scout failure

aw '79

contractor and called for five more vehicles in order to complete Phase I.

Of these five launches, all from Wallops, both orbital attempts ended in failure while the three non-orbital missions flew successfully. The first orbital attempt carried the LaRC-built S-55 micrometeoroid satellite as payload but failure of the Antares IA stage to ignite resulted in an Atlantic impact after an altitude of 70 mile had been reached. The backup payload to S-55 was orbited within two months by ST-6 but again the flight (payload operation was still a secondary objective within this developmental phase) was classified as a failure because the initial perigee of 61.9 miles gave the satellite a lifetime of only three days. Blame for this situation fell on the third/fourth stages separation system which involved a 'hot' separation. The third stage burned out at the planned 530,000 ft and remained attached to the other upper stages to provide control and guidance until it was released after fourth stage spin up and ignition. A frangible diaphragm joined the two stages, forming an internal clamp at the threaded periphery. Blast pressure of the fourth stage motor ignition ruptured the diaphragm, released the threading and allowed the stages to separate – a simple method which was also employed on the first/second and second/third stage interfaces. The trouble with it on the third/fourth stages was that the deflection to the trajectory caused by the presence of a diaphragm was much greater than with the other interfaces because of the much-reduced mass above the motor in use. Recognition of the problem with the ST-6 launch led to a 'cold' separation system in which the sequence of events was slightly different from the 'hot' system. Spin-up still took place first, followed by separation with explosive bolts and springs and then ignition.

This rearrangement solved the problem but it required much more complicated engineering than the 'hot' system. Since the problem would have been just the same for any future fifth stage, the same procedure was later adopted for fourth/fifth stage separation. First flight of the new system came with ST-8 in what was also the first Scout reentry mission, with the NOTS-17 fifth stage reaching a velocity of 22,500 fps. Since this was the first reentry flight and the first use of a five stage Scout, the mission is worth describing. The flight sequencing is quite different from orbital and probe missions because speed is all important. For ST-8 the schedule called for the Algol first stage to burn out at 50,000 ft and T + 41.3s with second stage ignition at T + 63.53s when the vehicle was at 125,000 ft.

A secondary objective of ST-8 was to photograph the second stage exhaust with a RAM camera pod mounted on the stage itself, with the pod ejecting after stage 2 burnout. In a normal Scout flight the second stage coast period lasted for about five seconds but in a reentry mission the upper stages and the dead second stage were allowed to reach a maximum altitude – in this case 705,000 ft – before third stage ignition occurred while the vehicle was beginning to descend. Third and fourth stage burnouts were planned to occur at T + 333s and T + 393s, respectively, followed by the NOTS-17 velocity package burning for 43s to take the payload down to 225,000 ft and up to a speed of about 19,000 mph. Langley provided the Reentry-1 payload for investigating aerodynamic heating at high speeds but the full speed was not reached in the descent despite the mission being tagged a success.

The two remaining flights of Phase I, ST-7 and ST-9, both flew successfully as upper atmosphere probes carrying experiments from GSFC (Goddard Space Flight Center) to look at ionospheric composition and electron densities. The first probe, P-21, was launched in early afternoon from Wallops while P-21A flew in the early hours of the morning so that comparisons could be made between readings taken at very different times of the day.

P-21A marked the end of a very important era in the life of the Scout launch vehicle because it was carried aloft by ST-9, the last developmental vehicle of Phase I. This period of ten launches had seen four successful probe flights but two out of three orbital attempts had been catalogued as failures. The single re-entry mission was logged as a success but it had not reached the speeds hoped for during experiment planning. However, the basic vehicle had shown itself to be sound after the problems of fourth stage separation were overcome and six successes out of nine flights at the very start of a launcher's career was a fair record, especially as one had involved five stages. In another sense, ST-9 marked a beginning. The Antares IIA (X-259) replaced the Antares IA as Scout's third stage and began a career which is not yet over. The first X-259 procurement contract was signed with ABL in June, 1961, calling initially for fourteen X-259 and X-258 motors for the rocket, following the development contract for both motors in September, 1960.

The X-259 was developed specifically for the Scout from the X-254 and improved the vehicle's capability as Fig. 4 shows with the Scout X-2 performance. In fact, the new third stage did not get to demonstrate its contribution to performance with the X-2 because, of the two X-2 missions flown, one was re-entry and the other was a failed orbital attempt. Its first orbital success had to wait until August, 1962 when it was part of a USAF-procured Scout X-2M. The early motors of the X-259A3 type were replaced by the B3 from the launch of September, 1967. Comparisons between performance figures for the X-259B3 and the X-254A1 show how much upgrading of the third stage took place in shifting from Antares IA to the IIA:

	Antares IA	Antares IIA	
Thrust	13,600	20,931	lbf
Burn time	39	36	sec
Total wt.	2700	2812	lb
Propellant wt.	2052	2575	lb
Length	132	114	ins

Phase II

So after the nervousness of the first flights of a new launcher, Phase II took over. These vehicles came from contract NAS1-1295 of May, 1961 covering thirty units (Phase III was included) worth $21.4 million to LTV. The declared intention of Phase II was to launch prototypes of the standard production vehicle over a period which eventually covered April, 1962 to November, 1963.

S-110 failure

Vehicle S-110 had to wait until September, 1962 before it was accepted from LTV and, as a result, was fired as the penultimate vehicle of Phase II. Launched from Wallops on 20 July, 1963, the rocket used the five stage X-3A configuration to carry the LaRC Re-entry-3 experiment to continue a series of flights started by ST-8 and S-114. After liftoff at 01:44:08 EDT S-110 was soon in trouble. At T + 2.5s a flame appeared above the first stage fins and two seconds later the stage base 'A' was engulfed by fire. The rocket's destruct system was activated by the failure and parts impacted around the pad within a one mile radius after S-110 had been in the air for a total of 32s. Early on after the incident it was clear the problem had been concentrated around the motor nozzle area and if this proved to be the case then the Scout programme was in severe difficulties because this particular type of first stage – Algol IIA – had flown successfully on eight previous missions and had been static fired no less than seven times. An investigation was soon initiated with the appointment of the

seven-man Scout 110 Review Committee which had to determine the cause and make recommendations to prevent a similar failure in the future. The Committee visited the launch site to examine what little debris of the nozzle had been recovered but evidence from the remains was not conclusive. Despite all the earlier successes of the Algol IIA motor the one used by S-110 differed from its predecessors in several, perhaps significant, ways, the major being that the nozzle had been produced by a new manufacturer, the Cincinnatti Testing Laboratory. By 30 July, the Committee was certain the nozzle failure had occurred because flaws in the nozzle structure had remained undetected during production and testing. Consequently, they recommended the redesigning of the nozzle, not because the original design was in itself poor but because, they felt, it should take more account of manufacturing difficulties. Aerojet submitted an updated design on 6 November, 1963 but to prevent Scout's launch schedule being interrupted too severely the Committee had earlier initiated the rebuilding and extensive qualification testing of four existing nozzles. This new testing showed up faults which had remained hidden during the original quality control inspection.

No problem arose from the nozzle on the next flight, of S-132 on 27 September, 1963 from WTR, but again the flight ended in failure when the third stage attitude control was lost during the long coast period prior to fourth stage ignition. The failure of the H_2O_2 system was demonstrated in ground tests to have been the result of excessive heating by radiation coming mainly from the hot nozzle of the exhausted X-259 third stage motor. The solution consisted essentially of additional insulation of components and a heat shield around the nozzle to block off heat to the attitude control system.

This failure emphasised the need for close cooperation between the manufacturer and NASA. Design interfaces, inspection and checkout procedures, field checkout and modifications procedures were revised with the objective of delivering to the launch site a certified vehicle needing no adjustments, minimum handling and essentially ready for launch. This was the main lesson to be learned from Phase II which was largely disappointing in its number of launch successes. Scout was aiming for a better than 90% success rate in its operational phase but the vehicles of Phase II had come nowhere near this figure. Out of fourteen flights, seven were classified as failures–a dismal 50%.

A break of three months was forced on the launch schedule between S-114 and S-115 while investigations went on into the three failures of the first four launches of Phase II. The failures of S-112 (self-destructed after second stage ignition) and S-114 were attributed to electrical problems and prompted the complete refurbishment of the wiring system and the upgrading of the ignition system and heatshield design. Three successes in a row seemed to show the major problems had been solved but then four failures in the last seven flights highlighted difficulties with third stage reliability and the poor quality control of Algol nozzle production. The failure rate and the investigations which showed inspection procedures were inadequate set the tone for Phase III of the Scout's career. The declared purpose of Scout was to provide a 'reliable' small payload launcher and, in this respect, it was most obviously failing. Phase III should have been the fully operational 90% success rate phase for the Scout after all the problems had been ironed out by the first 23 launches but instead it turned into a fierce drive for reliability by NASA and LTV. The resounding success of Phase III says something for the determination and capabilities of all the parties involved and, as we will see, Phase III achieved a success rate of 93%, far removed from the combined rate of 57% for Phases I and II.

On a more positive note, Phase II did introduce the X-258 (Altair IIA) fourth stage motor. We have seen how the problems of Algol IIA manufacture and quality control disrupted the launch schedule but which were overcome in the end; the X-258 got off to a better start, although there were problems with low thrust, and to date it has flown successfully in various versions on all of its 28 Scout missions. It was developed by ABL as part of a contract signed in September, 1960 to replace the X-248, with the first flying in June, 1963 as fourth stage of S-113.

X-258 (Altair IIA) history

Type	Scout vehicle
B1	113, 122, 132
C1	123, 124, 125, 128, 129, 134, 137
C2	133, 135
C3	136
E5	162, 176, 178
E6	141, 142, 143, 138, 139, 140, 156, 155
RHE6	154, 157, 149
E8	146

It has now largely been replaced by the FW-4S but there are some motors which have been in storage for about ten years as engineers continuously work to extend their useful shelf-lives.

Phase III

The solution to the problem which had destroyed S-132 in flight during September, 1963, was easy enought to implement but the failure had a more important overall effect by highlighting the poor reliability of the Scout during Phase II. It is no coincidence that Phase II came to an end with S-132 because that flight put into motion a comprehensive all-systems design, reliability, quality and processing review which showed dramatic changes had to take place in order to produce a reliable launcher.

An immediate problem was to ensure that the Scouts already completed and in storage awaiting launch were suitable. This required returning them to Dallas where they were completely disassembled and inspected and their components subjected to intensive scrutiny. All but the final two vehicles of the May, 1960 NAS1-1295 contract for vehicles 110 to 139 had been accepted from the manufacturer at the time of this follow-up contract in December, 1963, three months after the failure of S-132. Those last two vehicles later formed the beginning of Phase IV. Phase III, though, is termed the 'recertification phase' because the vehicles underwent a thorough check before they were pronounced suitable for launch. Their Scout numbers have an 'R' added to signify this recertification after refurbishment.

Other changes in the programme did not have such immediate results but they were no less important. The manufacturing and launch teams were brought much closer together to improve contact between the two groups; for example, a 'tiger team' followed checkout of each vehicle from Dallas to the launch site. New in-plant and launch site processing was introduced to integrate the two areas with the aim of delivering fully assembled, checked out and certified Scouts to the launch site where they would need a minimum of work. The vehicles completed in this way, for Phase IV and after, have a 'C' added to their numbers to indicate factory certification. Some also have an 'R' to show they were sent back to Dallas for some reason despite their original certification. Scout 144CR is an example.

The review showed the need to look carefully at the Scout's flight environment by providing more flight instrumentation and that the drive for reliability was more im-

portant than pressing ahead with programmes to improve performance with new motors. Also, the need was there to implement an incentive scheme for LTV and its subcontractors based on costs, delivery targets and flight success.

LTV began to take more responsibility; for example it was planned they would procure motors themselves (NASA had done it previously) and accept and store them at Dallas. This was part of the plan to send complete rockets to the launch site instead of assembling them in the field. This was also the reasoning behind the idea of air transporting the Scouts from the factory in Dallas. The feasibility of this was first demonstrated when S-131 was checked out, assembled and flown from Wallops to LaRC by a C-133 aircraft on 15 May, 1964 (S-131 was eventually launched in August, 1965). After the return by air on 27 May, it was inspected and announced to be still flightworthy despite its journey.

As we have seen, the idea of Phase III was to get Scout back on target for a success rate of at least 90% by launching recertified rockets. This it did spectacularly in its series of fourteen flights from December, 1963 to August, 1965 during which time it suffered only one failure.

Scout 130R/RFD-2

The eighth launch of Phase III took aloft a payload which investigated a problem highlighted by the recent controversy over the re-entry of Cosmos 954 and its radioactive-fuel cannister. The AEC (Atomic Energy Commission) developed a 490 lb payload for RFD (Re-entry Flight Demonstration)-2 to follow up the launch of RFD-1 by Scout 116 in Phase II to look at 'generator disassembly and fuel capsule burnup rate' during re-entry. The launch was made during darkness at Wallops so that the payload could easily be tracked during its descent into the denser regions of the Earth's atmosphere. A substitute material was carried to represent the radioactive fuel. The launcher itself was of particular interest because it was the first three-stage Scout, in the form of an X-3C, to be used, although it did carry a magnesium load cannister in place of the fourth stage motor.

Scout 124R/SERT-1

The main items of the 375 lb payload on this 47 minute suborbital flight were two ion engines being tested in space for the first time. The engine from LeRC (Lewis Research Centre) fired successfully in its 19 minute programme with a thrust of 0.00637 lbf and was subjected to a further test of some 9½ minutes after the other engine could not be made to operate.

Explorer

Seven of the payloads in Phase III were Explorer satellites of various functions which will be discussed later in a section on Scout and Explorer as a whole.

S-128R failure

The only failure of Phase III came with the firing in June, 1964 of Scout 128R with a classified USAF satellite. First stage operation was normal but soon after second stage ignition the rocket self-destructed anf fell into the ocean. The culprit is believed to have been an electrical signal which caused the shaped explosive charge normally used for range-safety destruct on the second stage motor to detonate. Since the autodestruct was activated so soon after second stage ignition, investigations on the ground centred on that area and the cause was isolated as a short in the destruct circuit wiring close to the separation diaphragm and ignition circuitry. As a result, a blast shield to protect components from high temperatures and debris was included in subsequent Scouts but introduction of the modified autodestruct system was not possible before the next two launches. Scouts 124R and 129R, therefore, flew without the systems and Scout had to wait until 134R before the new production design was added, successfully.

Apart from its overall success, Phase III also saw the first tangible results of US cooperation with Italy in the launch of the San Marco 1 satellite by an Italian team from Wallops. Although launches from the San Marco platform in the Indian Ocean did not occur until later Phases, the project did begin early in the history of the Scout so we will now briefly consider that aspect of the story.

San Marco

The San Marco complex was set up to satisfy the need for an equatorial launch site for small to medium payloads which could not be handled by existing Scout facilities in the US. NASA was eager to expand its international projects and Italy wanted a satellite programme of its own in the 1960s. In October, 1961 the Italian Space Commission headed by Professor Luigi Broglio sent a group to LaRC to present its San Marco proposals to NASA with this stated objective:

"The project San Marco will be performed under the cooperation between the NASA and the Italian Space Committee, and it will have as objective the launching of a scientific satellite in an equatorial orbit by means of a Scout vehicle launched from a mobile base consisting of two floating platforms with moveable legs."

The initial satellite launch was recognised as merely being a first objective which would be followed by further international projects.

The understanding between the two nations was signed in May, 1961 and it set out the project in three sections:

Section 1
- Train Italian launch crews;
- Train launch and range safety crews for Shotput;
- Flight test principle elements of the satellite by Shotput
- Begin San Marco launch complex design.

Section 2
- Train Italian teams for Scout assembly, check-out. Launch and range operations;
- Orbit prototype of the satellite by Scout from Wallops

Section 3
- Orbit satellite from San Marco platform by Scout;
- Establish fully operational equatorial launch facility.

The US agreed to supply training, launch vehicles and tracking while the Italians were to provide the launch complex, launch crew and satellite. The Italian Foreign Minister and the US Vice-President signed the full official agreement in September, 1962.

Launch crew and spacecraft designers came from the Centro Richerche Aerospazial (CRA) of the University of Rome and it was men from this group who joined their American counterparts at LTV in Dallas for factory training from August to October, 1963, during which time they became thoroughly familiar with the construction and processing of Scout 137. They moved up to Wallops the following August to join the launch crews who actually processed the vehicles in the field and participated in the handling of five Scouts (launches 29 through 33) before they fully took over the processing of Scout 137R which was to carry aloft the prototype San Marco satellite. The successful launch of San Marco 1 took place on 15 December, 1964 during Phase III, making Italy the first nation after the two superpowers to orbit their own payload.

Before the launch training had taken place, however, the first two launches of the programme had occurred under Section 1 of the agreement. In order to test-fly the Italian-

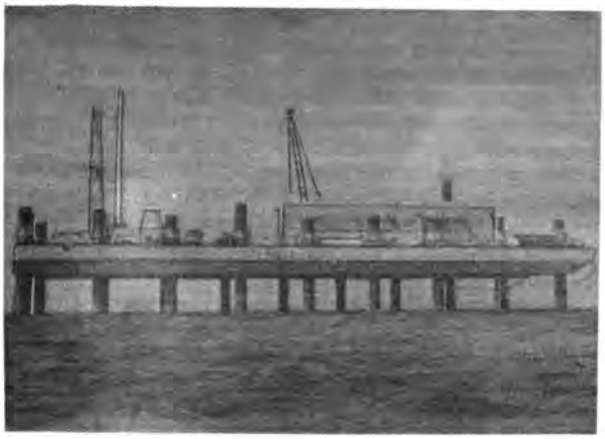


Fig. 8. The San Marco complex, anchored off the coast of Kenya, provides the launch site for Scout's equatorial firings. It has used Mark II equipment – the building on the right is the removable shelter – in all of its eight, successful, orbital attempts.

NASA

Fig. 9. Scout S-187C is raised to its firing position with the British Ariel 5 satellite sitting within the 34-in heatshield and the African coast in the background.

NASA

built principal elements of the satellite, two Shotput vehicles left over from the Echo 1 suborbital inflation tests were pressed into service and launched in April and August, 1963.

The location for the San Marco platform had to provide an eastward-looking range free of inhabited areas for as far as possible. The site chosen was Formosa Bay in the Indian Ocean, three miles off the coast of Kenya in international waters. The complex consisted of two platforms, the first, San Marco, leased off the US Army and the second, Santa Rita, obtained from the Italian Oil Company (ENI). Santa Rita was towed to Africa during December, 1963 and Janu- 1964 while San Marco left Charleston, South Carolina during May, 1965, *en route* to La Spezia in Italy for modifications. In November, 1966 both platforms were towed to Formosa Bay where the range was integrated, checked out and validated between December, 1966 and February, 1967. San Marco acts as the actual launch pad while Santa Rita (Figs. 9 and 10) is occupied by the launch crew for launch and tracking and data acquisition.

As part of the range checkout, Scout-144 was shipped to San Marco in January, 1967 to take part in mock countdowns before the first flight vehicle, S-153, arrived to launch San Marco 2.

As had been described earlier, the payload and final stages were usually balanced on a spin table at the launch site shortly before launch. This system was difficult to adopt for San Marco because the satellite was in Italy, the spin facility was at Wallops and the launch site was on the other side of Africa! To have followed the usual procedure would have involved some 8,000 miles of travel with the final problem of shipping the fully assembled final stages to Africa. In the end, the payload and fourth stage were balanced separately and mated at San Marco in time for a successful launch on 26 April, 1967.

Since that time, seven further satellites have been launched from San Marco (Table 4) and more are planned for the future. The orbiting of Explorer 42 in December, 1970 was the first occasion on which an American satellite had been launched by a foreign agency.

The range does have the capability to handle Scout reentry and probe missions if downrange tracking ships are provided for full trajectory coverage and sounding rockets can also be flown from the platform.

S-131R – Scout Evaluation Vehicle

The final launch of Phase III was a very important flight for the programme because the whole vehicle was subjected to intense scrutiny during flight and because many changes had been made to the configuration at one time in an attempt to establish the form of the standard launch vehicle. This was signified by the change over from the 'X' designations to the new terminology for this flight of the Scout B. The success of 131R on 10 August, 1965 showed the extensive changes were justified and provided flight planners with a great deal of environmental information. This last item, it will be remembered, was the objective of one of the recommendations made at the start of the recertification programme.

Two of the major changes brought in the Castor II and FW-4S motors for the first time. Castor II differs considerably in design from the Castor I becasue propellant weight has been increased by 900 lb as a result of both an increase in density and alteration of the internal grain contour. The result is a 70% thrust increase in vacuum over Castor I. The FW-4S fourth stage produced some 20% more thrust in vacuum than its X-258 predecessor. On a smaller scale, two of the four spin rockets on the fourth stage spin table were used for the first time. Normally four 0.6KS40 (40 lbf thrust) motors were carried but the SEV vehicle introduced the 1.0KS75 (75 lbf thrust) motors.

Another important first was the use of 'yaw torquing'. This capability meant that the orbital inclination of a satellite was no longer completely restricted by the location of the launch site but could be set to suit the type of payload. 'Dog-legging' was a valuable addition to the Scout's capabilities.

Other aspects of the misison were:

(1) The rocket had been transported by air in a simulated coast-to-coast flight;

(2) Fourth stage interchangeability was demonstrated in which the fourth stage and payload were spin-balanced in such a way that they were suitable for attachment to any vehicle without further balancing;

(3) The successful operation of the 'E' transition section and its improved separation system was achieved.

(4) Detailed measurements of motor performance and environmental data were obtained. Performance figures came from a velocity meter system which measured axial acceleration from liftoff to termination of fourth stage thrust.

The objective of establishing a standard Scout vehicle was so vital that the Army's Secor 5 geodetic satellite was carried as an extra item. The payload upper weight limit was a mere 50 lb since so much extra instrumentation was carried.

The jump in payload capability resulting from the inclusion of the new Castor II and FW-4S motors is shown in Fig. 4 by comparing the performance achieved by Scout B1 with that of the X-4, one of the highest energy Scout types flown prior to the mission of Scout 131R in 1965.

Phase IV

Phase IV covers the period from November, 1965 to June, 1971 and is usually termed the 'Systems Management' phase of Scout because the system of vehicle production recommended after the failure of S-132 in Phase II was first fully adopted for most of the Scouts built for Phase IV. It will be remembered the Phase III Scouts were built before the accident and had to be recertified for flight. The vehicles of Phase IV, however, carried a 'C' to indicate their factory certification, although the first two flights of the Phase were of Scouts from the original Phase III contracts and carried the 'R' of that series.

The vehicles were contracted in May, 1963 while Phase II was still operating, but the motor contracts were spread over the period from April, 1964 to June, 1966.

It is unlikely that the quantity of launches of Phase IV will ever be equalled–22 orbital and 3 re-entry misisons–and the success of Phase III was continued with only two failures. This 92% success rate was spread over 15 launches for DoD and 10 for NASA or, in terms of vehicle type, 10 Scout As, 12 Scout Bs, 2 Scout X-4s and a single Scout X-4A. These last figures show how this was the first Phase to use mainly standardised Scouts. We note also that Scout A was launched for the first time and its success was closely linked with that of the B since they differed only in the type of fourth stage they carried. The first launch from the San Marco platform in the Indian Ocean took place in mid-Phase.

The first failure came with the launch of a Cambridge Research Laboratory satellite for the Air Force by S-151C in January, 1967 when everything went smoothly until seven minutes after liftoff when a graphite insert in the FW-4S motor nozzle failed and the motor case ruptured. The next B launch, from San Marco in April, 1967, used a redesigned insert.

The second failure of Phase IV came with the launch of Esro IIA in May, 1967. The International Radiation Investigation Satellite (IRIS) was built under an ESRO-NASA contract of July, 1964 and carried seven experiments for solar astronomy and cosmic ray studies from polar orbit. All went well with the launch until the wall of the X-259A3 third stage motor burned through and caused the vehicle to be destroyed some 202s after liftoff. ESRO had to wait a full year before the backup satellite could be launched successfully on Scout 161C, the penultimate Phase IV vehicle.

S-144CR/PAET

One of the most interesting launches of Phase IV was that of S-144CR and its Planetary Atmosphere Experiments Test (PAET) re-entry payload in June, 1971, The spacecraft was 25 in long and 36 in. in diameter with a blunt cone forebody and hemispherical afterbody and was designed to satisfy the primary objectives of investigating a means of determining the structure and composition of an unknown planetary atmosphere.* However, it was the Scout vehicle itself which was of particular interest because of its long history before it was launched some five years after the other 140-series rockets.

It was originally assigned to a Navy payload but later given over to PAET. The highlights of its history are:

- June, 1964 accepted from LTV and stored.
- Feb, 1966 shipped from Dallas to Wallops.
- Jan, 1967 shipped to San Marco to qualify facilities.
- Mar, 1967 into storage.
- Apr, 1967 shipped to Wallops.
- Jly, 1967 displayed at LaRC.
- Oct, 1967 into storage.
- Nov, 1967 to Dallas for recertification.
- Mar, 1971 to Wallops for launch.
- Jun, 1971 launch.

So its career spanned seven years before it was flown as the final vehicle of Phase IV. It was also the first Scout to incorporate the large 42 in diameter payload shroud.

Phase V

Because S-144CR was so late in being launched to complete Phase IV, there was considerable overlap between Phase V and its predecessor (Fig. 11). Phase IV ran from November, 1965 to June, 1971 although its penultimate vehicle was launched in May, 1968, close to the start of Phase V (April, 1968 to December, 1971). To add to the confusion, a Phase VI Scout was also launched while Phase V was still operating.

The contract for fifteen Scouts was signed with LTV in August, 1966 and it included the money for the company to buy the stage motors themselves. NASA had procured the motors previously. Thus Phase V was known as the 'Incentive Procurement' phase.

The Scout had by now settled down to achieve the success which had been so elusive in the early days and it only remained for Phase V to continue that success. History shows us that out of fifteen launches (11 orbital, 3 re-entry and 1 probe) there were no failures. Contrast this with seven failures out of 23 launches for Phase II.

No less than twelve of the fifteen missions were carried out by the 'B' but the other three are interesting nevertheless because they all marked milestones of some significance in Scout's career. The basic 'A' vehicle made its last appearance, while the 'D' made one of its first flights. The remaining flight is tied in with a series of investigations flown by LaRC and would probably not have been made had the Scout been more successful during Phase II; in the 1950s and 1960s a great deal of research effort went into looking at re-entry heating problems of spacecraft returning from

* *To aid in designing spacecraft for such missions as Pioneer Venus 2, which released probes into the Venerian atmosphere.*

orbit and LaRC was one of the foremost research centres in this field with their Scout Re-entry Heating Project.

By 1967 LaRC had flown five of these re-entry missions (see below), the fourth of which carried a sample of Apollo heatshield material.

Scout	Re-entry Speed (fps)	Mission
ST-8 (X-1A)	22,500	Re-entry 1
114 (X-3A)	–	Re-entry 2
110 (X-3A)	–	Re-entry 3
129 (X-4A)	22,922	Re-entry 4
141 (X-4A)	26,854	Re-entry 4B
164 (X-5C)	19,572	Re-entry 5

Two failures meant that a great deal of data was lost and, after a review of hypersonic boundary layer research, NASA concluded there was a need for more flight data for comparison with ground-based results. A further Heating Project was therefore deemed desirable and Re-entry-F was ordered. All the other Project flights had used five-stage Scouts of some description together with normal heatshields but Re-entry-F was flown by the only X-5C ever used, with its three stages topped by a 13 ft long cone. This type of payload was designed to return information on conditions similar to those in re-entry of advanced spacecraft whereas the earlier flights had investigated the more immediate problems of Apollo-type re-entry. The mission was launched from Wallops on 27 April, 1968 and was declared a success.

The first 'D' launch came with Phase VI but because of overlapping Phase V also had its own 'D' flight. In June, 1969 LaRC awarded a $2.5 million contract to LTV for the design, development and qualification of the Algol III motor for use as the first stage of a new Scout variant, the 'D' engineering studies showed the new motor would enable Scout to orbit a 400 lb payload in a 300 mile orbit, a one-third increase over the performance of Scout B. An important feature of the motor is that its enlarged diameter did not force any changes in the rest of the vehicle, the launch tower, ground hardware or test equipment.

Comparing the Algol III with its IIC predecessor:

	IIC	III	
Length	358	375	in
Diameter	40	45	in
Burn time	76	56	s
Thrust	98,147	108,815	lbf
Weight	23,799	31,345	lb

Apart from some planned B-1 launches, the Algol III has now taken over from the IIC as Scout first stage and is to be found on the D, E, F and G versions. The first Scout D with Algol III, flew as the third Phase VI vehicle but the last Phase V launch was also with a 'D', carrying Explorer 48 from the San Marco platform off the coast of Africa. This launch could be termed the Scout's 'coming-of-age' because, despite its earlier difficulties, the Scout took over the record for the longest run of continuous successes of a NASA rocket–26. Scout eventually took this to 37 before the failure of S-196 in May, 1975 brought the run to its end.

We have already discussed one of the re-entry missions of this Phase but LaRC also ran a second re-entry programme which resulted in two further Phase V re-entry flights. One of the most troublesome problems of a spacecraft re-entering the Earth's atmosphere is that of radio blackouts caused by the vehicle being surrounded by an ionised plasma sheath of material. With manned spacecraft the blackout period is one of the most dramatic and worrying times for ground controllers. Three Scout re-entry RAM (Radio Attenuation Measurement) missions launched during Phases IV and V looked at this problem and some possible solutions. RAM C-1 successfully demonstrated the effectiveness of adding water to the plasma flow field around the re-entering body and the use of X-band telemetry signals in penetrating that field. The launch was originally scheduled for 13 October, 1967 but two delays, one because of payload problems and the other because of poor weather conditions in the launch area, slipped the liftoff date to 19 October.

The 264 lb RAM C-2 completed its eight minute ballistic flight on 22 August, 1968, gathering data on electron concentrations in the plasma sheath as re-entry took place at medium velocities. The cone-shaped spacecraft–15in and with 26 in base diameter–tapered to a 12 in diameter hemispherical nose.

RAM C-3 completed the series in 1970 when it re-entered the atmosphere at 24,032 fps after reaching a maximum altitude of 465,000 ft.

Explorer

The Explorer series of satellites has had a long and distinguished connection with the Scout launch vehicle with 21 out of 55 spacecraft orbited by that rocket. This record is not surprising in view of the fact that Explorer was designed to be a series of *small* scientific satellites, well within the Scout's capabilities. Most of the others, either heavier or or requiring more exotic orbits than the Scout could handle, were launched by the more powerful Delta.

The first orbital launch attempt by Scout carried the Explorer S-56 balloon aloft but failure meant the first Scout orbital success had to wait until the next vehicle, ST-4, and its Explorer 9 payload. Scout was to launch three more balloons–Explorers 19, 24 and 39–in a LaRC programme to investigate the density of the upper atmosphere. Earlier balloon-satellite attempts by Vanguard, Juno I and Juno II had all failed.

Explorer 39 was one half of the Air Density-Injun Explorer launched in August, 1968. Its companion studied incoming solar radiation during a period of maximum solar activity while the balloon obtained air density measurements to correlate with those from the Explorer 24 balloon in 1964, a time of minimum solar activity. The Explorer 24/25 success marked the first NASA launch of two satellites by the same carrier, while Explorer 39/40 was Scout's second dual launch.

The other Explorer/Scout launches can be divided into three categories:

1. Micrometeorite satellites: Explorers S-55, 13, 16, 23 and 46.
2. Ionospheric physics satellites: Explorers 20, 22 and 27.
3. Radiation satellites: Explorers 30, 37, 40, 42, 44, 45, 48, 52 and 53.

Explorers S-55, 13(S-55A), 16(S-55B), and 23(S-55C) formed a family of satellites built around the fourth stage of the Scout designed to relay data on micrometeorite impacts. Explorer 46 (Meteoroid Technology Satellite) investigated the efficiency of using a double spacecraft wall as protection against micrometeorite penetration, showing this method was six times more effective than using a single wall of equivalent width.

The two Beacon Explorers, Explorers 22 and 27, carried laser reflectors and radio beacons for accurate position

findings for geodetic work but their main function was to transmit a continuous series of radio signals through the ionosphere to more than 80 ground stations in order to study the ionosphere. Explorer 20 also investigated the ionosphere, by taking radio 'soundings' at six frequencies to contribute to a programme known as 'Topside Sounder'.

The radiation satellites can be split further into those spacecraft which studied particle radiation interacting with the Earth's magnetic fields and those which looked at high energy electromagnetic radiation of astronomical interest. In the latter category, Explorers 30, 37 and 44 studied X-ray and UV radiation from the Sun while Explorers 42, 48 and 53 (the Small Astronomy Satellite series) looked at X and γ rays from galactic and extragalactic sources. Explorer 42, the first US satellite launched by another country, began the work now being continued by the HEAO observatories.

Explorer 52 ('Hawkeye') in the former category was launched by the only Scout E flown so far, into a highly-eccentric orbit with an apogee of 125,000 miles and a perigee of some 2,000 miles in order to study the interaction of the solar wind with the Earth's magnetic field. Explorers 40 and 45 studied the particle radiation in regions closer to the Earth.

Phase VI

Although Phase VI is considered to have been in operation between July, 1971 and February, 1975, the fifteenth and final vehicle of the phase, S-192C, has been held over as a standby launcher for the Navy satellite series. Otherwise, Phase VI achieved a perfect launch record in its fourteen orbital attempts.

The contract for the Phase VI vehicles was signed with LTV in April, 1968 and the first Scout (178C) was put into storage in March, 1969 before being launched in October, 1974. The launch record of Phase VI differs considerably from previous phases because:

- The 'D' type was used in quantity for the first time;
- The first 'E' was launched;
- The first 'A1' was launched;
- 'B-1' vehicles were used instead of the basic 'B'.

The A-1 and B-1 variants differed from their parent vehicles by using the Algol IIC instead of the Algol III as first stage.

The E-1 launched in June, 1974 marked the first use of the BE-3A (Alcyone 1A) in the Scout programme although, as was described earlier, it was originally intended for the 'C'.

The Alcyone 1A is only a small motor, some 32in in length and 19in in diameter with a thrust of 6,188 lbf, a burn time of 8½ s and a total weight of 217 lb. but it does considerably uprate Scout's performance for some orbits. For a 124 x 2500 mile orbit from the San Marco platform it increases the 110 lb total payload for a four stage Scout to 143 lb–a 30% improvement. The 'E' also used the first of the new Antares IIIA third stages.

Phase VI is also notable for its high proportion of international launches–Esro, Aeros, San Marco, Eole and the three UK satellites (Table 5). The Ariel programme grew out of an offer made to COSPAR by the US in March, 1959 to launch foreign payloads when the experiments carried were of mutual scientific interest. Ariels 1 and 2 were both built by the US and carried some British experiments in their investigations of the ionosphere, ozone layer, micrometeorites and galactic radio noise. Ariels 3 and 4 were built by BAC to look at space conditions which affect the radio-reflecting properties of the ionosphere.

The next UK satellite was not part of the Ariel series but was one of the X series of technology satellites originally intended for launch by the British national launcher, Black Arrow. UK-X4 'Miranda' (its X3 predecessor was named 'Prospero') carried five technology experiments to investigate the problems of three-axis stabilisation, solar cells, star, IR and albedo sensors. The launch of X4 was of particular interest to some three quarters of a million Boy Scouts in America and Britain because their signatures were carried into orbit under the 'First in Space' project in microdot form on a decal applied to the casing of the fourth stage motor. It is no coincidence that Abraham Leiss, Assistant Head of the Scout Project Office, is also vice-president of the Boy Scouts of America! (Fig. 14).

Ariel 5 differed considerably from its predecessors and it became the first British X-ray satellite, continuing the pioneering work of Explorer 42 and OAO 3 by looking at cosmic X-ray spectra. Ariel 6 will continue the investigations into the X-ray sky, marking the 100th firing of Scout.

Phase VII

This latest part of Scout's career is still underway and should end during 1980 or 1981. LaRC awarded the contract to LTV in May, 1972 for 15 vehicles to follow up the successful Phase VI and we have already seen the introduction of a new Scout type, the F-1. This is the current basic configuration but its reign will be shortlived because the G-1 is soon to be introduced. The F-1 differs from the previous D-1 basic vehicle by using the Antares IIB motor for the third stage instead of the less powerful Antares IIA. In fact, the F-1 is simply an E-1 without the Alcyone 1A fifth stage.

The two planned F-1 Scouts have already been launched and the second one, S-196C, brought the run of 37 consecutive successes for Scout to an end in December, 1975 when the Antares IIB nozzle failed in flight.

Probe missions

The fourth launch of Phase VII saw the seventh probe mission of the rocket's history, illustrating how small a proportion of Scout flights have involved probes. In contrast, there have been twelve re-entry missions. The first two followed simple probe trajectories because the Scout was being fired for the first time. Launch 76 in September, 1971 took aloft a joint West German/NASA barium-ion-cloud (BIC) probe to study the behaviour of a barium cloud released at several Earth radii into the Earth's magnetic and electric fields. Because ground stations needed excellent visibility in order to observe the cloud as it spread, the launch had to take place in exceptionally fine weather. As a result, S-166C went through 17 countdowns over a period of five months before conditions were deemed to be suitable.

Gravity Probe, the final probe mission, carried a unique experiment to test Einstein's General Theory of Relativity five hundred times more accurately than was previously possible. The idea was to put a very accurate clock into a weakened gravitational field and compare its timekeeping with a duplicate clock kept back on Earth. The difference was so small–less than 1 part in 10^9–that the test had to wait until the Smithsonian Astrophysical Laboratory could build a hydrogen maser clock with a frequency stability of 1 part in 10^{15} (or 2s in 10^8 years!). The 235 lb payload reached an altitude of over 6,000 miles in a two hour flight out over the Atlantic.

Scout G-1

The latest Scout variant, the G-1, is scheduled for its first launch in September, 1979 when it will carry Magsat into orbit. Table 3 shows the 'G' is similar to the 'D', 'E' and 'F' types except that a new third stage, the Antares IIIA, is being employed. The $2¼ million contract for the design, development and qualification of the new motor was signed in November, 1976 to include three development firings in the

early summer of 1978 and three qualification firings in late 1978 to early 1979. Fig. 4 shows the improvement in performance by introducing the new stage but despite this the number of planned 'G' launches is not very high for the coming years. It will replace the 'F' as the standard vehicle but we can see by looking at an October, 1977 projection of future Scout usage just how few launches there are going to be:

Phase VII		(1975-1980)
Scout		type
198	UK-6	D-1
199	Navy 23	B-1
202	SAGE	D-1
203	Magsat	G-1
204	NOVA 1	G-1
205	NOVA 2	G-1
206	NOVA 3	G-1
207	S. Marco	G-1

Phase VIII		(1980-1985)
Scout		type
208	S. Marco	G-1
209	Navy 25	G-1
210	Navy 26	G-1
211	Navy 27	B-1
212	Navy 28	B-1

Phase IX	
213	SME
214	AMPTE-A
215	AMPTE-B
216	ABRES-A
217	ABRES-B

This planning is very tentative and the final list may appear very different—the Shuttle has already probably taken away the AMPTE payloads from Phase IX. As an example of the difference between planned and actual launches, the 1971 projection for 1976 showed:

UK-6	OFO-B
Navy 19	SAGE-A
Navy 20	HCMM
San Marco	Navy 21

In reality it turned out to be:

Navy 18 (from 1975)
Gravity Probe (from 1975)
STP75-6

In other words, the schedule for 1976 contained none. of the payloads listed five years earlier.

Three of the G-1 launches are intended for Nova, satellites which will replace the Transit navigation system in use since 1967. The spacecraft will continuously transmit signals to indicate their positions to allow ships to determine their own locations by the Doppler method, similar to Transit but much quicker and more accurate. The satellites will weigh about 300 lb in orbit and use 25 ft-long booms for gravity-gradient stabilisation.

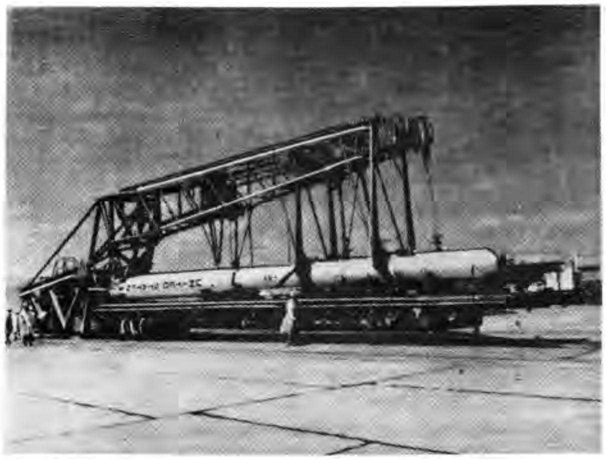


Fig. 10. The Mark II launch complex, introduced at WRT for launch 10 and at Wallops for launch 28, allows Scout to be checked out in the horizontal position. A moveable base allows launch azimuth to be varied between 65° and 205° and the cantilevered elevating launch boom raises the vehicle upright for launch.

NASA

There are no firm plans for any new Scout variants after the 'G' but there is a possibility that the new Antares IIIA third stage will be teamed up with an old type first stage—there are still several Algol IICs in the inventory from the Phase VI contract of April, 1968—to produce the H-1 version. The outcome depends not only on future payload requirements but also on the state of the old motors which have now been in storage for a decade while engineers continue to work on extending their useful lives. When a vehicle is required for a payload the SPO is given at least a year's notice and a vehicle is assigned to the mission from the inventory but budgetary restraints mean that the present inventory is quite small and almost all of the vehicles have been taken up. Five vehicles are on order for delivery in 1980, after a period of fabrication lasting two years for each Scout.

After the launch of UK-6 in 1979 there are no more Scout missions planned for Wallops.

Scout exhibits

Presently there are three Scout rockets on display to the public:

- At Wallops—made up of unwanted items, for display around the country;
- At the Air Force Cambridge Laboratory in Cambridge, Massachusetts—D9, the last Blue Scout.
- At the National Air and Space Museum (NASM) in Washington, DC—this was put together with test hardware (e.g., motor cases after test firing) by LTV personnel. Several photographs of this display were used earlier in Fig 1.

Acknowledgements

The author would like to thank Karen Miller (LaRC Public Affairs), Lee Foster (Head, SPO) and Joe Talbot (Head, SPO Operations Unit) for their kind help in the preparation of this article. A special mention of appreciation must be made to Abraham Leiss (Assistant Head, SPO) who gave up a great deal of his valuable time to provide most of the information and photographs.

Reference

1. Gatland, K.W., *Spacecraft and Boosters*, Iliffe Books, 1964.
2. Christy, Robert D., Satellite Digest-98', *Spaceflight*, 1976, p. 411.

	Scout	Type	Date	Site	Payload	
1	ST-1	X-1	1 Jly 60	WI	P	
2	ST-2	X-1	4 Oct 60	WI	P	
3*	ST-3	X-1	4 Dec 60	WI	S	Explorer S56
4	ST-4	X-1	16 Feb 61	WI	S	Explorer 9
5*	ST-5	X-1	30 Jun 61	WI	S	Explorer S55
6*	ST-6	X-1	25 Aug 61	WI	S	Explorer 13
7	ST-7	X-1	19 Oct 61	WI	P	P-21
8	ST-8	X-1A	1 Mar 62	WI	R	Reentry 1
9	ST-9	X-2	29 Mar 62	WI	P	P-21A
10*	111	X-2	26 Apr 62	WTR	S	Solrad 4B
11*	112	X-2M	24 May 62	WTR	S	(USAF)
12	117	X-2M	23 Aug 62	WTR	S	(USAF)
13*	114	X-3A	31 Aug 62	WI	R	Reentry 2
14	115	X-3	16 Dec 62	WI	S	Explorer 16
15	118	X-3	18 Dec 62	WTR	S	Transit 5A
16	126	X-3M	19 Feb 63	WTR	S	(USAF)
17*	119	X-3	5 Apr 63	WTR	S	Navy 2
18*	121	X-2M	26 Apr 63	WTR	S	(USAF)
19	116	X-3	22 May 63	WI	R	RFD-1
20	120	X-3	15 Jun 63	WTR	S	Navy 3
21	113	X-4	28 Jun 63	WI	S	(USAF)
22*	110	X-3A	20 Jly 63	WI	R	Reentry 3
23*	132	X-2B	27 Spt 63	WTR	S	(USAF)
24	122R	X-4	19 Dec 63	WTR	S	Explorer 19
25	127R	X-3	27 Mar 64	WI	S	Ariel 2
26	125R	X-4	3 Jun 64	WTR	S	Navy 4
27*	128R	X-4	25 Jun 64	WTR	S	CRL 2
28	124R	X-4	20 Jly 64	WI	P	Sert 1
29	129R	X-4A	18 Aug 64	WI	R	Reentry 4
30	134R	X-4	25 Aug 64	WTR	S	Explorer 20
31	130R	X-3C	9 Oct 64	WI	R	RFD-2
32	123R	X-4	10 Oct 64	WTR	S	Explorer 22
33	133R	X-4	6 Nov 64	WI	S	Explorer 23
34	135R	X-4	21 Nov 64	WTR	S	Explorer 24/25
35	137R	X-4	15 Dec 64	WI	S	San Marco 1
36	136R	X-4	29 Apr 65	WI	S	Explorer 27
37	131R	B	10 Aug 65	WI	S	Secor 5
38	138R	X-4	18 Nov 65	WI	S	Explorer 30
39	139R	X-4	6 Dec 65	WTR	S	FR-1
40	140C	A	21 Dec 65	WTR	S	Navy 5
41	142C	A	28 Jan 66	WTR	S	Navy 6
42	141C	X-4A	9 Feb 66	WI	R	Reentry 4B
43	143C	A	25 Mar 66	WTR	S	Navy 7
44	145C	B	22 Apr 66	WTR	S	OV3-1
45	146C	A	18 May 66	WTR	S	Navy 8
46	147C	B	9 Jun 66	WI	S	OV3-4
47	148C	B	4 Aug 66	WTR	S	OV3-3
48	149C	A	17 Aug 66	WTR	S	Navy 9
49	150C	B	28 Oct 66	WTR	S	OV3-2
50*	151C	B	31 Jan 67	WTR	S	OV3-5
51	154C	A	13 Apr 67	WTR	S	Navy 10
52	153C	B	26 Apr 67	SM	S	San Marco 2
53	155C	A	5 May 67	WTR	S	Ariel 3
54	156C	A	18 May 67	WTR	S	Navy 11
55*	152C	B	29 May 67	WTR	S	Esro IIA
56	157C	A	25 Spt 67	WTR	S	Navy 12
57	159C	B	19 Oct 67	WI	R	RAM C-1
58	158C	B	4 Dec 67	WTR	S	OV3-6
59	162C	A	1 Mar 68	WTR	S	Navy 13
60	160C	B	5 Mar 68	WI	S	Explorer 37
61	164C	X-5C	27 Apr 68	WI	R	Reentry 5
62	161C	B	16 May 68	WTR	S	Esro IIB
63	165C	B	8 Aug 68	WTR	S	Explorer 39/40
64	168C	B	22 Aug 68	WI	R	RAM C-2
65	167C	B	3 Oct 68	WTR	S	Esro IA
66	172C	B	1 Oct 69	WTR	S	Esro IB
67	169C	B	7 Nov 69	WTR	S	Azur
68	176C	A	27 Aug 70	WTR	S	Navy 14
69	171C	B	30 Spt 70	WI	R	RAM C-3
70	174C	B	9 Nov 70	WI	S	Ofo 1
71	175C	B	12 Dec 70	SM	S	Explorer 42
72	173C	B	24 Apr 71	SM	S	San Marco 3
73	144CR	B	20 Jun 71	WI	R	PAET
74	177C	B	8 Jly 71	WI	S	Explorer 44
75	180C	B-1	16 Aug 71	WI	S	Eole
76	166C	B	20 Spt 71	WI	P	GRP
77	163CR	B	15 Nov 71	SM	S	Explorer 45
78	183C	B-1	11 Dec 71	WTR	S	Ariel 4
79	184C	D-1	13 Aug 72	WI	S	Explorer 46
80	182C	B-1	2 Spt 72	WTR	S	(USAF)
81	170CR	D-1	16 Nov 72	SM	S	Explorer 48
82	185C	D-1	20 Nov 72	WTR	S	Esro IV
83	181C	D-1	16 Dec 72	WTR	S	Aeros 1
84	178C	A-1	29 Oct 73	WTR	S	Navy 16
85	190C	D-1	18 Feb 74	SM	S	San Marco 4
86	188C	D-1	8 Mar 74	WTR	S	UK-X4
87	191C	E-1	3 Jun 74	WTR	S	Explorer 52
88	186C	D-1	16 Jly 74	WTR	S	Aeros 2
89	189C	D-1	30 Aug 74	WTR	S	ANS
90	187C	B-1	15 Oct 74	SM	S	Ariel 5
91	194C	F-1	8 May 75	SM	S	Explorer 53
92	195C	D-1	11 Oct 75	WTR	S	Tip 2
93*	196C	F-1	5 Dec 75	WTR	S	DAD
94	179CR	B-1	22 May 76	WI	S	STP75-6
95	193C	D-1	18 Jun 76	WTR	P	GP
96	197C	D-1	1 Spt 76	WTR	S	Tip 3
97	200C	D-1	27 Oct 77	WTR	S	Transat
98	201C	D-1	26 Apr 78	WTR	S	HCMM

*=Scout failure
WI=Wallops Island
WTR=Western Test Range
SM=San Marco

S=satellite
P=probe
R=reentry

Scout Configurations (through launch 98)

type	stage 1	stage 2	stage 3	stage 4	stage 5	no. used
X	Algol IA	dummy	Antares IA	dummy	-	1
X-1	Algol IB, IC	Castor IA	Antares IA	Altair IA	-	7
X-1A	Algol IC	Castor IA	Antares IA	Altair IA	NOTS-17	1
X-2	Algol IC, ID	Castor IA	Antares IIA	Altair IA	-	2
X-2B	Algol ID	Castor IA	Antares IIA	Altair IIA	-	1
X-2M	Algol ID	Castor IA	Antares IIA	M-2	-	3
X-3	Algol IIA	Castor IA	Antares IIA	Altair IA	-	6
X-3A	Algol IIA	Castor IA	Antares IIA	Altair IA	NOTS-17	2
X-3C	Algol IIB	Castor IA	Antares IIA	-	-	1
X-3M	Algol IIA	Castor IA	Antares IIA	M-2	-	1
X-4	Algol IIA, IIB	Castor IA	Antares IIA	Altair IIA	-	13
X-4A	Algol IIB	Castor IA	Antares IIA	Altair IIA	NOTS-17	2
X-5C	Algol IIB	Castor IIA	Antares IIA	-	-	1
A	Algol IIB	Castor IIA	Antares IIA	Altair IIA	-	11
A-1	Algol IIC	Castor IIA	Antares IIA	Altair IIA	-	1
A-2	Algol IIC	Castor IIA	Antares IIB	Altair IIA	-	0
B	Algol IIB	Castor IIA	Antares IIA	Altair IIIA	-	25
B-1	Algol IIC	Castor IIA	Antares IIA	Altair IIIA	-	5
B-2	Algol IIC	Castor IIA	Antares IIB	Altair IIIA	-	0
C	Algol IIC	Castor IIA	Antares IIA	Altair IIIA	BE-3	0
D-1	Algol IIIA	Castor IIA	Antares IIA	Altair IIIA	-	13
E-1	Algol IIIA	Castor IIA	Antares IIB	Altair IIIA	-	1
F-1	Algol IIIA	Castor IIA	Antares IIB	Altair IIIA	-	2
G-1	Algol IIIA	Castor IIA	Antares IIIA	Altair IIIA	-	0

Alternative motor designations :

Algol IA ... Aerojet Senior
Castor IA ... XM33E5, XM-75
Castor IIA ...TX354-3
Antares IA ...X-254, XM-70
Antares IIA...X-259
Altair IA ... X-248, XM-69
Altair IIA ... X-258, XM-94
Altair IIIA ...FW-4S, TEM640-1
NOTS-17 ... NOTS100-17, XM-78
BE-3A ... Alcyone IA

Heatshield Types

(data through S-177)

Type		No.	Comments
A	20 +4.8	5	1st 5 flts
B	25.7+5	1	ST-6
C	25.7+13	1	ST-5
D	21.5-10	3	ST-7 to 9
E	34 -10	4	
F	25.7-5	4	AF Scouts
G	34 -25	5	
H	25.7-15	1	S-114
I	25.7-10	1	S-132
J	34 -40	2	S-163, 170
K	42 -45	1	S-144

'UK' satellites

UK-1	Delta,62	Ariel 1
UK-2	27. 3.64	Ariel 2
UK-3	5. 5.67	Ariel 3
UK-4	11.12.71	Ariel 4
UK-X4	8. 3.74	Miranda
UK-5	15.10.75	Ariel 5
UK-6	1979	Ariel 6

San Marco milestones

1963	Italian crews begin training
15 Dec 64	Italian crew launch San Marco 1 from WI on S-137R
1964-67	San Marco complex under construction
26 Apr 67	First launch from San Marco (San Marco 2 on S-153C)
12 Dec 70	Launch of Explorer 42 from SM by S-157C
24 Apr 71	Launch of San Marco 3 from SM by S-173C
15 Nov 71	Launch of Explorer 45 from SM by S-163CR
16 Nov 72	Launch of Explorer 48 from SM by S-170CR
18 Feb 74	Launch of San Marco 4 from SM by S-190C
15 Oct 74	Launch of Ariel 5 from SM by S-187C
8 May 75	Launch of Explorer 53 from SM by S-194C

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SLOW PROGRESS AT THE CAPE

On 1 May, an hour behind schedule, at 8.30 am, the Orbiter Enterprise began the 3½ mile journey to Launch 39A at the Kennedy Space Center. The object was to put Enterprise and its inactive components through their paces to allow technicians to make sure ground support equipment will be compatible with the 'Columbia', writes Gerald L. Borrowman.

The roll-out delay was caused by a minor communications problem between the 50 observers assigned to watch over the Shuttle combination as it moved out from the Vehicle Assembly Building (VAB). The job of the observers was to make sure the Shuttle combination did not hit any work platforms surrounding the space vehicle.

At 9.45 am. as rain pelted the area of Launch Complex 39, I watched from beside Firing Room 4 of the Launch Control Center. The words of the former director of the Kennedy Space Center, Dr. Kurt Debus, returned to my mind. Several days before in the Cocoa Beach Theatre Dr. Debus had recounted his first viewing of Columbia in the Orbiter Processing Facility. "It (Columbia) looks almost clumsy". He continued to express reservations about the Space Shuttle configuration and that he intended to have a lengthy conversation with Dr. George Mueller, now the Chairman and President, System Development Corporation, and formerly the Director of the Office of Manned Spaceflight, about the Shuttle.

Now watching the ungainly configuration on its way to the launch pad my memory returned to problems that plagued Apollo 4. No previous mission had been so plagued by vexatious delay, due in part to the teething troubles of a new rocket and new stages. However, the delays were not unproductive. Many involved the learning of lessons that, once mastered, were needed in succeeding Saturn V launches.

In 1979 one of the most vexatious components was the Space Shuttle Main Engines (SSME's) for Columbia. Their delivery was to be delayed by another 30-days. This delay was the result of a serious engine fire that broke out on a test engine after an oxygen valve broke down. The three engines slated for use in Columbia were being tested at NASA's National Space Technology Laboratory at Bay St. Louis, Mississippi, and were expected to be delivered somewhere between 15 June and the end of that month.

While the problem with the engine valve had been corrected the launch for STS-I had slipped to the very end of the year or early 1980. Problems with developing, preparing and funding Shuttle systems were the major cause of delay. John F. Yardley, NASA's associate administrator for space transportation systems expressed the view that the first Space Shuttle could be launched on 21 December. Rockwell International officials, however, were working toward a launch date in late-January.

The delay in installing the tiles of the thermal protection had been alleviated in that some workers were to be brought to the KSC from California. The hope was that at least 650 tiles per week would ultimately be installed. At the end of April only 200 tiles had been fitted.

The delays had caused some Air Force officials to express concern at not having a Shuttle ready for flight for at least three years. The delay means an additional $200 million would be needed in NASA's 1980 appropriations. One possible source of funds was to take the $270 million for construction of the three additional Orbiters. This reallocation of funds would cause a six-month delay in the commencement of final assembly of the second Orbiter, called Challenger. Challenger was slated to be operational in 1981.

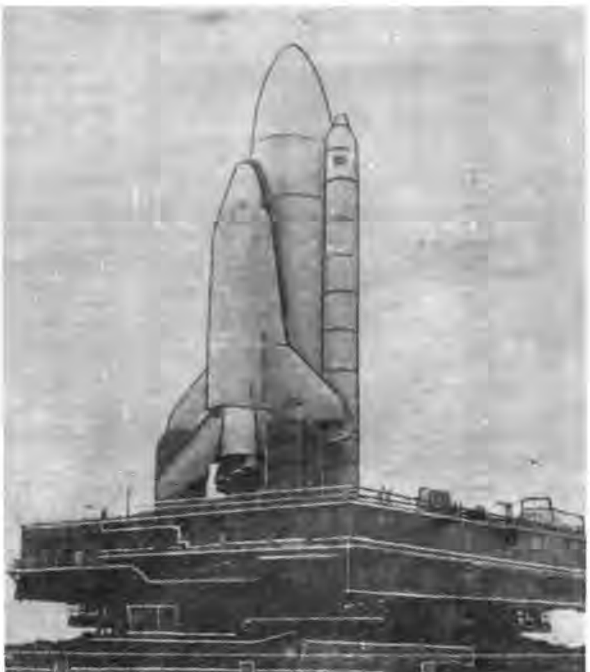
While the Air Force could sustain a six-month delay, any further loss of time would interfere with the construction of satellites that could only be launched by the Shuttle.

Six weeks after Columbia had arrived at the KSC, Dr. Walter Kapryan, the launch director expressed the view that he was "basically satisfied" with the preparatory work on the Orbiter. He did, however, express regret that more thermal tiles had not been fitted. Since Columbia's arrival 444 tiles out of more than ten-thousand had been installed. Tile installation personnel would rise from 311 to 465.

Dr. Kapryan went on to say that the "pathfinder" project was moving along smoothly. Power-on testing to test Columbia's compatibility with the launch processing system proved successful. Only minor problems related to computer programmes and various commands had been encountered during computer and electrical tests.

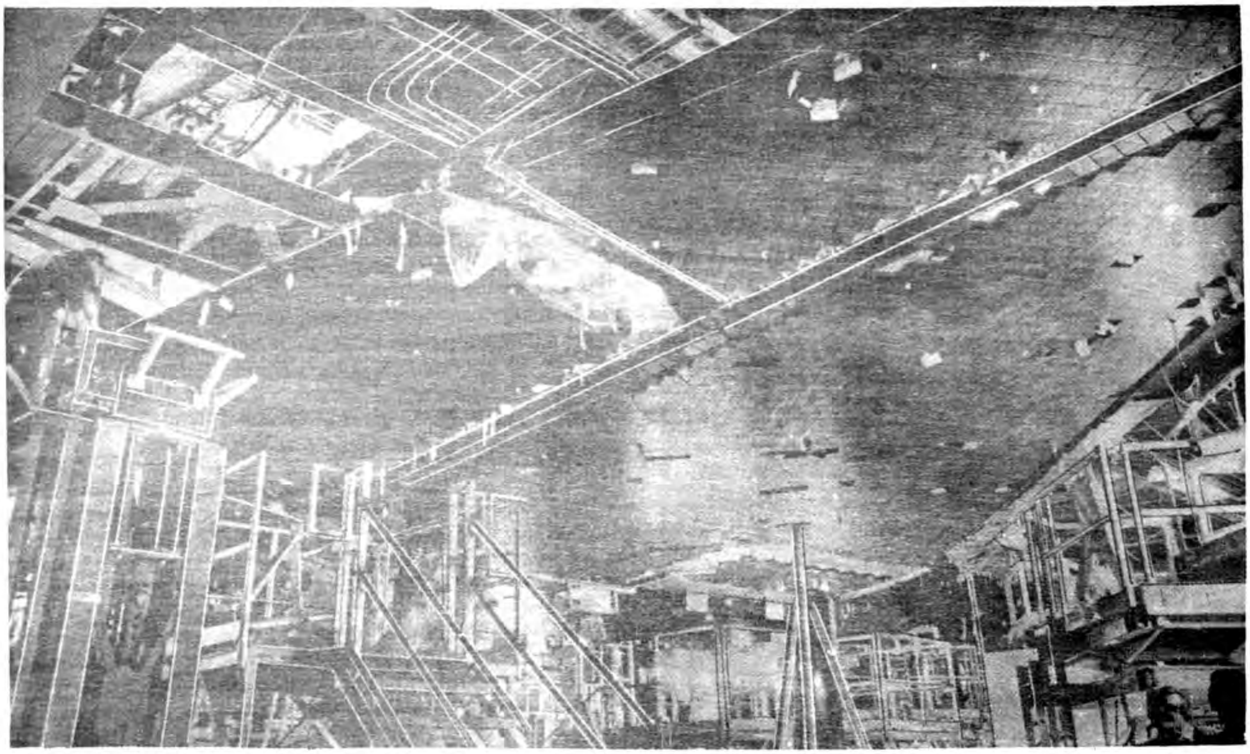
On Thursday, 10 May, a firing of the first of the three SSMEs had to be cut short when instrumentation cables failed about half-way through the 520-second test. However, two earlier tests were successful for shorter durations. The test when repeated two days later was successful. The other two flight-worthy engines were to be tested shortly.

A full-duration cluster firing of the SSMEs was delayed on 16 May because a propellant feed line for the single engine ruptured during a test firing at Rocketdyne's Santa Susana, California, facility. The rupture caused a small fire in the engine area. Officials at Bay St. Louis stated that the three-engine 520 second burn would be conducted when a cause had been found for the Santa Susana incident.



Space Shuttle Orbiter 'Enterprise' is rolled out of the Vehicle Assembly Building for the 3½ mile journey to Launch Complex 39A.

NASA



Work underway on Columbia in the Orbiter Processing Facility fixing on the silica fibre thermal insulation tiles. Picture shows almost completed starboard underside wing. Columbia should make the first Shuttle flight sometime next year.

Photo by Stephen Smyth

Left. Checkout of the Rocketdyne Space Shuttle Main Engine (SSME) is conducted on the A-3 test stand at the division's Santa Susana Field Laboratory, near Chatsworth, Calif. As evidenced by this mainstage operation photo, the flame of the SSME's high performance liquid oxygen and liquid hydrogen propellants is essentially transparent. The world's most advanced rocket engine, the SSME, produces 470,000 lbs. (2,090,560 newtons) of thrust utilising the high performance propellants, an efficient staged combustion cycle, and a high main combustion chamber pressure. A cluster of three engines will provide propulsion of the Space Shuttle Orbiter.
Rockwell International Corporation, Rocketdyne Division.

The same day NASA Administrator Robert Frosch decided to request an additional $220 million from Congress. This action was decided upon instead of shifting the funds previously budgeted for Orbiter production. The funds, if approved, would be used to purchase more equipment and manpower needed to prepare the Columbia for its first flight.

The expected total Shuttle project costs will be about $8,000 million, which is more than $2,500 million more than NASA's original estimate.

The questions of three Senators about the quality of the Shuttle's management team caused Administrator Frosch to conduct "an overall assessment of the space transportation systems" management. The probe was headed by NASA deputy administrator Robert Lovelace. Assisting in the management evaluation are Richard C. McCurdy, former administrator for organisation and management, and Willis H. Shapley, former NASA associate deputy administrator. Also involved were Air Force Major Gene. James Abrahamson; F-16 programme director; A. Thomas Young, deputy

The slow process of fixing the tiles to the Shuttle. A technician works on Columbia in the Orbiter Processing Facility during May 1979.

Photo by Stephen Smyth

director of NASA's Ames Research Center; John E. O'Brien, NASA's assistant general counsel for procurement, and Abraham Spinak, associate director of NASA's Wallops Research Center.

In a memo to Lovelace, Frosch instructed the probe to explore the difficulties "with vertical and horizontal communications".

On 21 May, a test of the sound suppression system used to muffle the blast of the Space Shuttle's engines failed. Instead of 300,000 gallons flooding the mobile launch platform in 28 seconds it took 8 minutes and 40 seconds. The cause was the failure of a single valve to open.

On 2 June, Space Shuttle launch director Dr. Walter Kapryan resigned from NASA. Kapryan publicly emphasised that his decision to retire was not based on a recent directive that operations personnel would not have overall control of the Shuttle programme at KSC. The directive called for Dr. Robert Gray's Shuttle programme office at KSC to be lead organisation in controlling the Shuttle project at the space center. This reorganisation decision was a sharp departure from previous manned space programmes in which space vehicle operations took control of a project once flight hardware began arriving at KSC.

During his career with NASA he was project engineer for the Mercury programme, head of the Gemini programme office and then assistant Apollo spacecraft programme manager at KSC.

George F. Page was immediately moved from his position as director of Shuttle Cargo operations and expendable launch vehicles to replace Kapryan. Page had been spacecraft test conductor on the Gemini programme, chief spacecraft test conductor for both Gemini and Apollo launch operations, and chief of the spacecraft operations division for Apollo, Skylab and Apollo-Soyuz Test Project missions.

Another departure from NASA was that of astronaut Fred Haise, effective the end of June. Haise has become vice president for space programmes at the Grumman Aerospace Corporation.

Selected as commander of the third Orbital Flight Test Haise commented:

"Jack (Lousma) and I were working with Vance Brand and Bill (Charles G.) Fullerton (the crew for the fourth Orbital Flight Test) as a four-member team and we had not gotten to the point where we were working in pairs with the simulators and other gear, so right now it isn't urgent to get someone to replace me immediately".

In the wake of NASA's decision to evaluate Shuttle management operations, Rockwell International decided to adopt a team approach in preparing Columbia for its first flight.

The team consists of the following: Thomas J. O'Malley, Rockwell's vice president and general manager of launch operations at KSC, who was given additional duties, including spacecraft checkout team leader, responsibility for master scheduling of Columbia activities plus support to a special "BUILD" team that will concentrate on preparing the spaceship.

Edward P. Smith, vice president and general manager of Rockwell's Shuttle Orbiter division, is the BUILD team's management leader with overall responsibility for the final assembly and testing of Columbia.

A third member of the management team is Dan Brown, director of production operations for the Orbiter division.

The month of June marked several important milestones for the participation of the US Air Force in the Space Transportation System. A group of specialists from the Air Force was to arrive at the Johnson Space Center to begin training for mission operations control support of Department of Defense missions aboard the Shuttle. At Vandenberg Air Force Base in California, the Air Force will spend over $1,000 million dollars during the next five years. This will entail a work force that will put in place some 200,000 cubic yards of concrete, 17,000 tons of steel and all the complex equipment necessary to launch the Shuttle from the West Coast site.

NASA/JAPANESE COOPERATION

The Joint NASA/Space Activities Commission of Japan Study Group has completed its work and submitted its final report to Dr. Robert A. Frosch, NASA Administrator, and Dr. Tsuyoshi Amishima, Acting Chairman, Space Activities Commission.

The joint study group was established last year to assess areas and methods of possible additional cooperation in space projects between NASA and Japan.

The group's report recommends initiation of preliminary steps which could lead to joint projects in the following areas:

- Study of winds and waves associated with typhoons.
- Study of ocean dynamics.
- Study of marine resources.
- Measurement of cloud height by satellite stereography.
- Reception of Marine Observation Satellite-1 data.
- Snow properties research.
- Potential evaporation studies.
- Study of crustal plate motions.
- Exchange of experimental communications satellite data.

- Collaborative study of Halley's Comet.
- Pre-entry science packages for the Saturn orbital dual probe mission.
- Transpacific balloon project.
- X-ray astronomy.
- Joint tether project.
- Origin of plasmas in Earth's neighbourhood programme.
- Collaborative solar studies.
- Spacelab life sciences studies.

Projects that are selected will be implemented by appropriate agreements between NASA and the appropriate counterpart agency in Japan.

In its review of potential areas of cooperation, the study group examined concepts for joint projects suggested by either side which were of mutual interest. The projects under consideration include both near-term efforts, such as the study of ocean winds and waves using existing satellite and surface truth data, and future efforts, such as the Saturn orbiter dual probe mission, which is in the early planning stage and is not an approved mission at this time.

Each side's responsibilities will be consistent with their respective scientific, technical and funding capabilities, and each would fund its own activities.

The study group was proposed by NASA during a meeting between Dr. A.M. Lovelace, NASA Deputy Administrator, and Dr. Amishima, on 17 July 1978. The study group met three times during the past year with the final meeting in Tokyo from 6-8 June.

ROOK BOOST FOR SKYLARKS

New versions of Britain's highly successful Skylark sounding rockets are in the pipeline. The rockets, being developed by British Aerospace Electronic and Space Systems at Bristol, employ more powerful boosters.

The first example, Skylark 14, is a development of the Skylark 7 two-stage rocket, several of which have been sold to the West German Space Agency (DFVLR).

Skylark 7s enable West German researchers to carry out experiments in space under conditions of microgravity of interest to the development of new metal alloys, composities, and semi-conductor crystals (to date, however, no comparable British work has been conducted with Skylark rockets).

The 14 has a Rook boost motor which greatly improves performance and payload, stepping up the time available for microgravity experiments to nearly eight minutes.

Skylark 15 is based on the Skylark 12 three-stage rocket, and also uses the more powerful Rook. This rocket is expected to reach altitudes of up to 937 miles (1,500 km) carrying a 220 lb (99.8 kg) payload.

INDIA FROM SPACE

India's Earth resources satellite Bhaskara, launched from Kapustin Yar on 7 June 1979, is being commanded to take pictures only during daytime passes over India, writes H. P. Mama. The two TV cameras are switched off when the satellite loses contact with the telemetry station at Sriharikota to conserve power. There are no ground stations outside India which can accept data from Bhaskara.

Remote sensing data are being collected from the Himalayan mountain chain as well as from the following Indian states: Uttar Pradesh; Gujarat, Madhya Pradesh, Rajasthan, Tamil Nadu, Karala and Karnatake.

Bhaskara is expected to collect data on snow melt and aid flood forecasting in the Himalayas; to collect data on the growth and decay of biomass in agriculture in Bihar and Gujarat, examine soil and land use in Karnataka, sea erosion in Kerala, forestry in Madhya Pradesh and Uttar Pradesh, ground water in Tamil Nadu, and the behaviour of deserts in Rajasthan. Other applications include study of the snow-line and maintain ecology east and north of Dehra Doon, wet land ecology in the Kutch riverine terrain, sedimentation deposit phenomena near the sea coast on the Narmada river, and forestry combined with river basin water management around the Nilgiris.

We have since learned that the ground station had difficulty in switching on the two TV cameras aboard Bhaskara. Ed.

"THE INDUSTRIALISATION OF SPACE"

Eighteen months ago the U.K. Department of Industry awarded a contract to the London-based company of General Technology Systems Limited to study the future industrialisation of space. Two industrial subjects were selected for closer examination: Materials processing in the unique environment of space stations and space power systems; the latter comprising massive space stations to generate electrical power to be then transmitted to Earth. This is the first officially sponsored study to be carried out in the U.K. on this important and far-reaching concept. Further preliminary surveys on two other subjects:- large multi-purpose space telecommunications stations ("Orbital Antenna Farms" in COMSAT terminology) and Earth observation from space, were to be carried out with a view to establishing whether they warranted a similarly close examination. The four reports of this study were recently handed to DOI on schedule.

The bulk of the study effort was devoted to space power systems and took the form of a critical study and assessment of proposals currently being examined by industry in the USA for government departments. This effort was shared between GTS and Space Department, RAE working as part of its internal programme for the Department of Industry. The Atomic Energy Research Establishment, Harwell, also made an expert contribution.

The RAE effort concentrated on a critical analysis of systems technologies in their various manifestations of design, performance and adverse effects and on an investigation of the requirements and characteristics of the massive and complex space transport on which every space power system will crucially depend.

The GTS effort in addition to co-ordinating the total task was directed towards the study of economic, legal, institutional, political, industrial and resources issue arising in the context of developing, constructing and operating space power systems. The space power system using solar photo-voltaic energy conversion emerged as an entirely credible engineering concept for providing base load electric power to Earth. In comparison with hydrocarbon or nuclear fuel burning systems of similar capacity its environmental impact seems mild and it promises economically competitive operation in the energy context of the future, largely on account of free, unlimited and uniterrupted delivery of primary energy. The industrial market generated by an operational space power system project may well run into tens of thousand million pounds (1978 prices) per year. However, a range of legal, industrial, institutional and political problems would need to be resolved before large scale use of space power systems can become a reality.

Clearly much further work remains to be done, in order to determine properly how the relevant capabilities of British Industry could be involved in such projects, and the relevance of such power generating systems to the U.K. demand in the years to come.

Good progress was made with respect to the further investigations on space processing, and the preliminary

assessments of future advanced space telecommunications and of remote sensing from space, referred to earlier, have indicated that whilst much thought has gone into the further development of techniques, too little is known about the probable combinations of time frames and extensions of applications which may be expected to take place over the next decade. The subjects of telecommunication *via* space and the observation of Earth from orbit, are of increasing importance, however, and the above subjects clearly warrant deepening attention again in the framework of UK Policy and industrial opportunity.

The study identifies fields of increasing commercial competition and technical complexity, in which the U.K. must maintain a strong position, with clearly planned objectives.

FRED W. HAISE one of four astronauts to fly the Space Shuttle Orbiter during Approach and Landing Tests. From right to left are Haise, Charles G. Fullerton, Richard H. Truly and Joe H. Engle.

NASA

SUCCESS OF OTS

It has been a case of success all the way for Europe's Orbital Test Satellite (OTS) which completed its first year in space on 11 May 1979. The pre-operational communications satellite in Clarke (geo-stationary) orbit is being used to prove the design and system engineering embodied in the European Communications Satellite (ECS), the first of which is scheduled for launch in 1981.

British Aerospace Dynamics Group—prime contractor to the European Space Agency on OTS leading the MESH consortium—has announced that the test satellite has exceeded the performance standards specified and is providing the telecommunications organisations of Europe with practical experience in the operational use of satellites. It has also demonstrated the ability to receive TV signals from small mobile ground stations and to transmit TV signals capable of being received by small mobile ground stations. These tasks were not envisaged in the original concept.

During its first year in space, the versatility of OTS as a TV link has been further demonstrated. It had been manoeuvred to beam TV signals to Cairo and, later, Rabat, where the transmissions were successfully received. French TV is now beaming signals to Tunisia via OTS for a further year of experiments.

With four wide band communication channels OTS can accommodate up to 7,200 telephone circuits, or a channel individually can handle one or two TV transmissions.

Under funding from the European Commission ground data equipment has been developed that enables OTS to be used in a data link joining the Rutherford Laboratory in Oxford with CERN in Switzerland and other national high-energy physics laboratories. In another data communications use, the Royal Aircraft Establishment at Farnborough has been linked with ESA establishments in Holland, Germany and Italy for computer communications data and document distribution, and teleconference communications using small ground stations at the establishments.

OTS has a design life of five years but is confidently expected to remain in service beyond that. In addition to its prime contractor responsibilities for overall design and project management of OTS, British Aerospace Dynamics Group developed certain flight hardware including the electrical power-conditioning and distribution systems, the pyrotechnics and the drive mechanisms and control electronics for the Sun tracking solar arrays.

OTS was launched on 11 May, 1978 by a Delta rocket from the Eastern Test Range, Cape Canaveral, Florida.

ASTRONAUT HAISE RESIGNS

Astronaut Fred W Haise, Jr. resigned from NASA at the end of June to join Grumman Aerospace Corporation, Bethpage, NY, as vice president for space programmes.

Haise started his NASA career as a research pilot at the NASA Lewis Research Center, Cleveland, in 1959. This was followed by three years at the NASA Dryden Flight Research Center, Edwards, California. He was one of the 19 astronauts selected by NASA in April 1966.

He was the Lunar Module Pilot for Apollo 13, April 11-17, 1970. The flight was to be a 10-day mission landing in the *Fra Mauro* region of the Moon. However, the mission was disrupted *en route* to the Moon because of the explosive failure of the Service Module cryogenic oxygen system, about 55 hours into the flight.

Haise and fellow crewmen, James A Lovell Jr., and John L Swigert Jr., working closely with the Houston ground controllers at the Lyndon B Johnson Space Center, converted their lunar module into a "lifeboat". Their emergency activation and operation of the Lunar Module systems conserved both electrical power and water in sufficient supply to assure their safe return to Earth.

Haise was the backup lunar module pilot for the Apollo 8 and 11 missions and the backup spacecraft commander for the Apollo 16 mission.

From April 1973 to January 1975, he was technical assistant to the manager of the Space Shuttle Orbiter Project. He was commander of one of the two two-man crews which piloted the Space Shuttle "Enterprise" on approach and landing test flights from June through October 1977 and had been named in March 1978 to command one of the early Space Shuttle orbital flights.

SPACE COMMUNICATIONS IN BRAZIL

The domestic satellite system being developed in Brazil will utilise communications equipment from Canada's Spar Aerospace Limited's Electronics Group, in Ste-Anne-de-Bellevue, Quebec. A $3.6 million contract from EMBRATEL (Empressa Brasileira de Telecomunicacoes) covers the supply of 500 voice channel FM SCPC (Single Channel per Carrier) units for the Earth stations that will provide automatic telephone and telex service to 13 communities in the Amazon Valley by 1980.

SPACE AT EAST FORTUNE

By Alan Lawrie

Introduction

Situated about 32 km due east of Edinburgh is the Museum of Flight at East Fortune Airfield. A large hangar on the now disused airfield has been made available by the Department of the Environment to house aircraft, rockets and other items. During the summer, visitors may come to this Royal Scottish Museum outstation to inspect the exhibits. This report deals with the rocket and satellite exhibits, both models and actual rockets.

Location of the Museum of Flight

By car the museum can best be reached from the A1 road. If approaching from the south, follow the A1 past East Linton until the B1347 branches off to the right. If arriving from the north, follow the A1 for 2½ km out of Haddington to the same turn-off. Follow the B1347 for 2½ km until a signpost indicates the turn-off to the museum on the right.

Alternatively, take the bus from Edinburgh to Haddington. Another bus from Haddington passes close to the Airfield, although a 10 to 15 minute walk is still required to reach the museum (see Fig.1).

Brief history

In its heyday during the first World War, the Airfield housed 1,500 officers and men of the Royal Naval Air Service.

Airships were flown from the Airfield, the most successful being the R34 which left East Fortune on 2 July 1919 to make the first transatlantic crossing by airship and the first ever two-way crossing by air.

Aircraft too operated out of East Fortune before the station was closed in 1920 as a result of post-war defence cuts.

During the second World War, when the present runways and hangars were built, East Fortune was the base for operational training units.

The last time the airfield was used on a large scale was for four months in 1961 when it became the airport for Edinburgh while the runway at Turnhouse was being resurfaced. During this time it handled 2,640 civil aircraft movements, carrying a total of 96,000 passengers.

Hangar number 1, known as the Bristol Hangar, because it was used by Bristol staff to maintain Blenheim, Beaufighter and Beaufort aircraft based at East Fortune, was opened to the public in 1975. Since then, every summer the public has been allowed to see the restored aircraft and space exhibits on show. Last year some 20,000 people visited the museum.

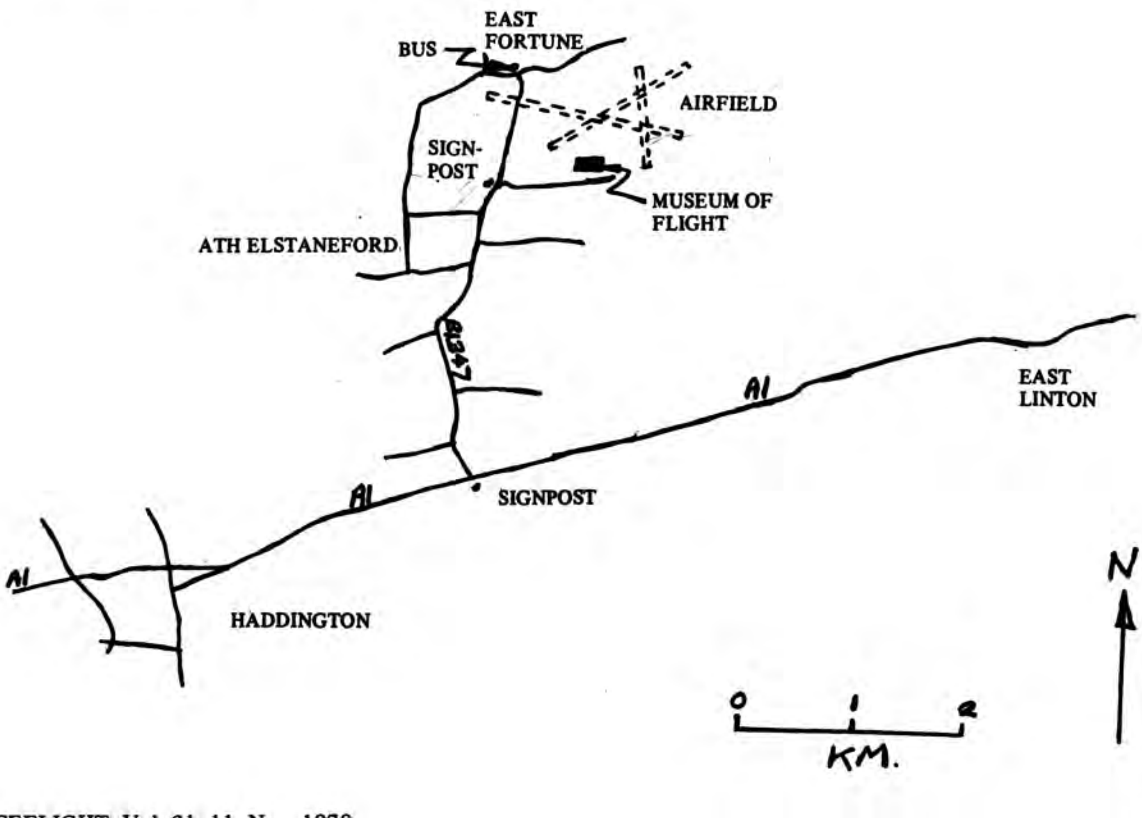
A further hangar, number IV, at present serves as a store for the items which cannot be accommodated in the main museum hangar, but it is intended to open part of this hangar to the public in the near future.

Rockets and satellites in hangar number 1

Blue Streak rocket (1964)

Originally intended as a MRBM, Blue Streak was cancelled as a military venture on 13 April, 1960. Powered by two liquid oxygen/kerosene-fed Rolls-Royce RZ-2 engines, the missile continued development as a part of the joint venture between Italy, Belgium, Holland, West Germany and France, known as the European Space Vehicle Launcher Development

Fig. 1. Location of the Museum of Flight.



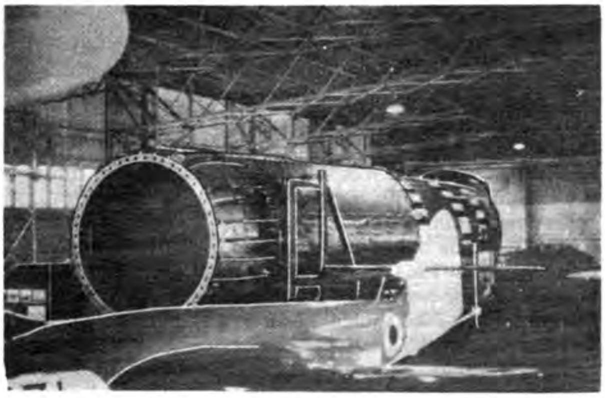


Fig. 2. Forward end of Blue Streak F-13 is visible in this photograph. In the foreground is a 1954 Hawker Sea Hawk.

All photographs by Alan Lawrie

Organisation. Fig. 4 shows the engine bay of Blue Streak F-13 which produced a thrust of 1,335 KN. at lift-off.

The main space exhibit is the Hawker Siddeley Dynamics Blue Streak rocket (Figs. 2, 3), 18.39 m. long. Presented to the museum by the European Launcher Development Organisation (ELDO) in 1973, this rocket was to have served as the first stage for Europa II F-13.

Although it never actually orbited a satellite, Blue Streak performed perfectly in 11 launches between June, 1964 and November, 1971. Faults with the French Coralie second stage and German Astris II third stage resulted in launch failures from Woomera and Kourou, in French Guiana.

News of the cancellation of the Europa programme on 27 April, 1973, came through with another Blue Streak, F-12, in Kourou and with F-13, the one in the museum, awaiting shipment to South America following static tests at Spadeadam in the north of England.

It is interesting to note that the Blue Streak rocket is unable to support its own weight unpressurised. When pushed slightly the extremely thin LOX tank wall panels bend inwards. The rocket on show is resting in a horizontal positionwith access to view the RZ.12 engine bay (Fig.5).

Black Knight rocket (1958)

Twenty-two Black Knight rockets were successfully launched from Woomera from 1958. Originally intended to pave the way for the Blue Streak MRBM, Black Knight was used in upper atmosphere research and re-entry studies. A version of the Cuckoo motor as used in the Skylark booster was employed as a Black Knight second stage, fired during re-entry to simulate the re-entry velocities of 4470 ms^{-1} to be encountered by Blue Streak.

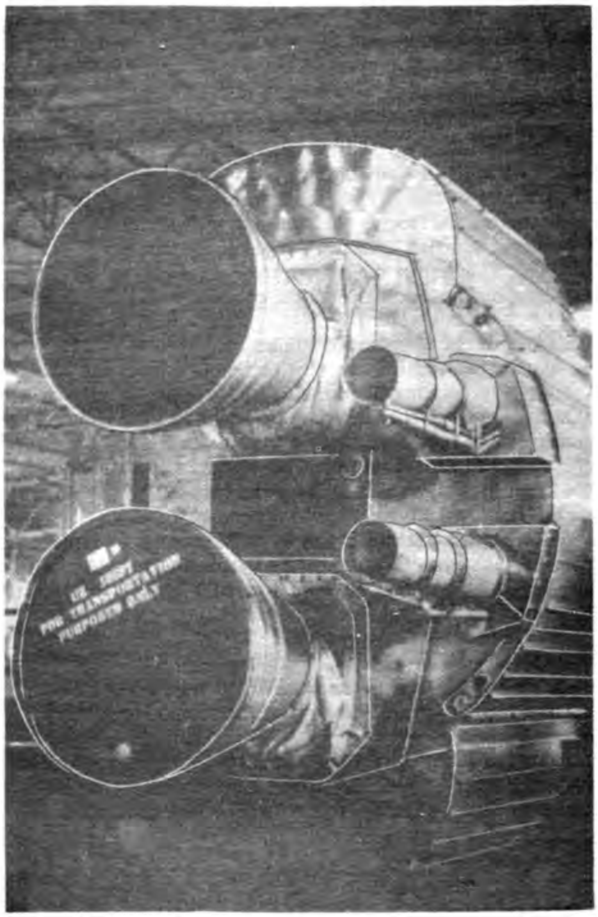


Fig. 4. Engine bay of Blue Streak providing a thrust of 1,335 KN.

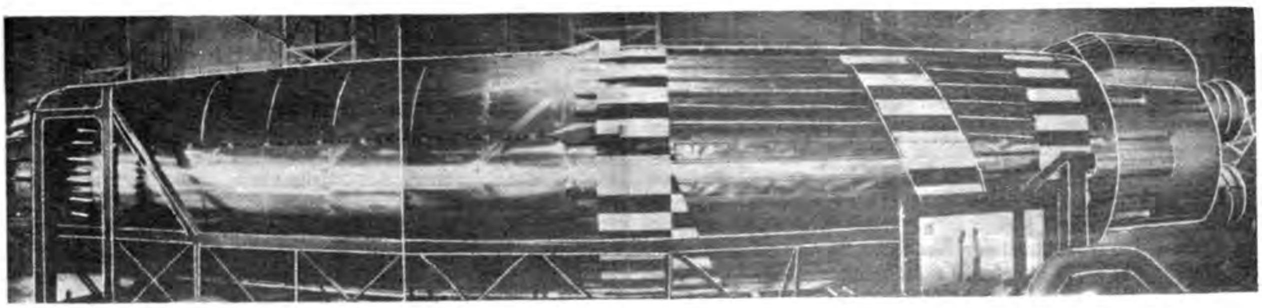
On 9 September 1964, the Minister of Aviation announced that the Government had decided to develop Black Knight into a more powerful rocket capable of launching British satellites. This rocket was the slightly longer Black Arrow. Black Knight had a length of 10.06 m. and a diameter of 0.91 m.

The Black Knight on show, presented by the MoD, is only partly visible at present as it is still in its transportation box.

Blue Streak ballistic missile model (1/5 size)

On top of the Black Knight box and alongside the real

Fig. 3. A panoramic view of Blue Streak.



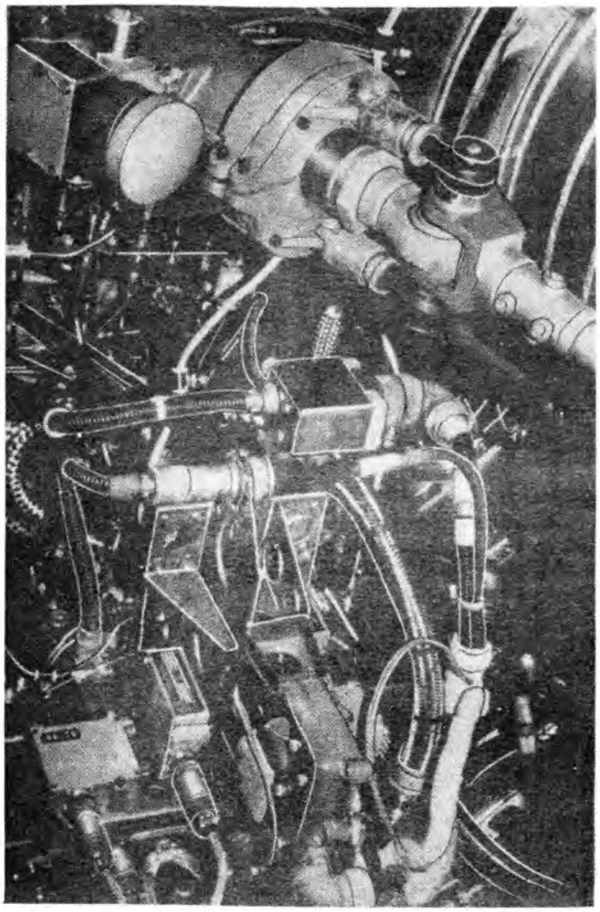


Fig. 5. Close-up of the engine bay compartment.

thing rests a Blue Streak model (Fig.6). This model, presented by Hawker Siddeley Dynamics, was the first model of Blue Streak to be released (1959).

RZ.2 Blue Streak rocket engine (1959)

A sectioned Blue Streak RZ.2 rocket engine built by Rolls-Royce apprentices at Spadeadam Rocket Establishment near Carlisle is one of several rocket engines on show and well worth a close examination.

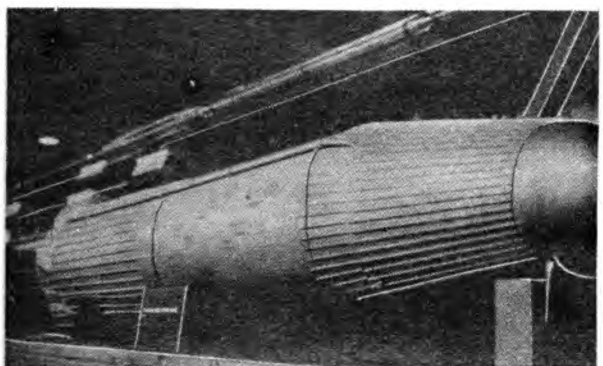


Fig. 6. First model of Blue Streak to be released; in the background, the real thing.

Providing the Europa I and II first stage thrust, the RZ.2 never failed in its 11 launchings.

The RZ.2 was developed by Rolls-Royce under the late A V Cleaver in the late 1950s, with the help of the Rocketdyne Division of North American Aviation Incorporated, who had developed the Atlas ICBM. The first engines were test fired in March 1959, and the first time they were used to launch a Blue Streak was in June 1964, when F-1 climbed away from the Woomera test range in Australia.

The final Blue Streak launching, from Kourou in November 1971, resulted in an explosion which was initially blamed on Blue Streak ("Blue Streak 'caused failure'" headlined *The Guardian* newspaper on 8 November 1971!), but which was subsequently traced to electrical interference in the German third stage systems, thus preserving the 100% British record.

Gamma 304 rocket engine (1964)

Fig. 7 shows the Gamma 304 rocket engine for the Black Knight at the Museum of Flight. Presented by Rolls-Royce ('71) Ltd., this hydrogen peroxide/kerosene-fed engine provided a thrust of 111.2 KN at sea level. The engine has four combustion chambers individually mounted on trunnions so that they may be swivelled for control about axes which are radial to the axis of the vehicle. The mass of the engine complete with the engine compartment, the hydraulic system for positioning the chambers, the electrical

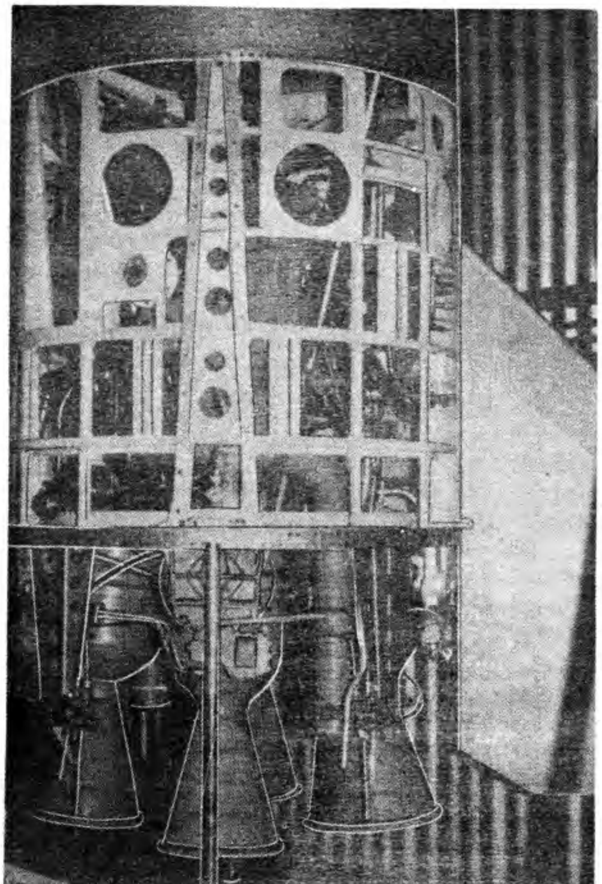


Fig. 7. Gamma 304 rocket engine for Black Knight, producing a thrust of 111.2 KN.

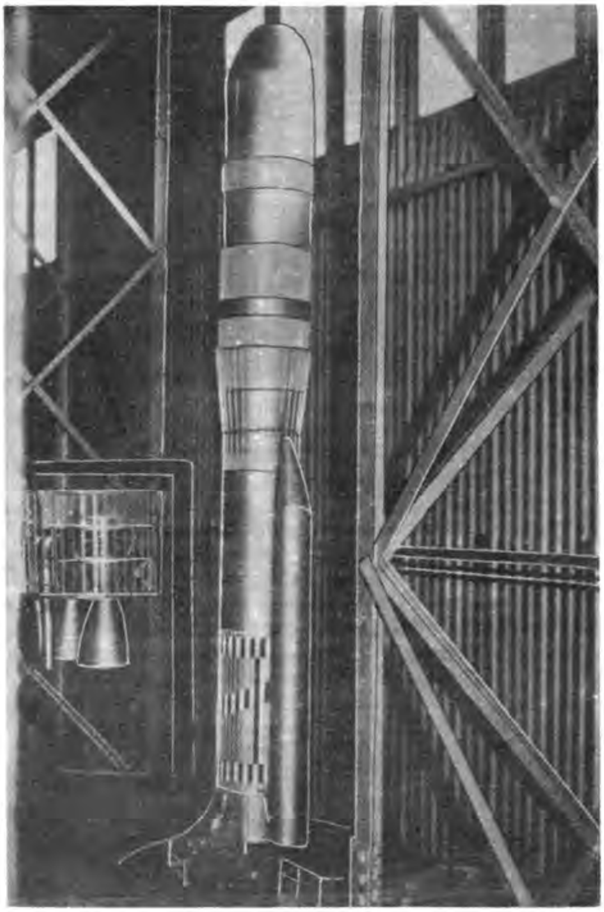


Fig. 8. A 1/10 size model of the proposed Europa IIIA rocket.

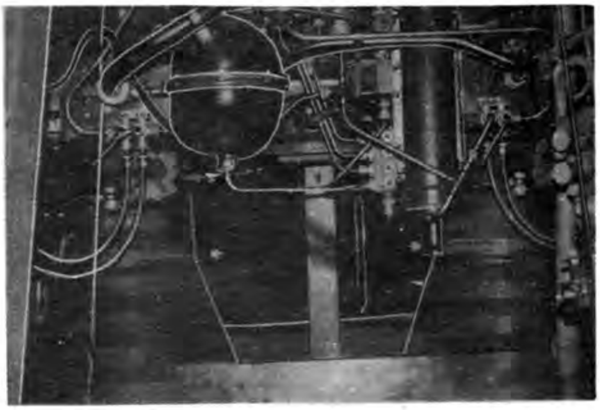


Fig. 9. Gamma BS625 plumbing prototype.

installation and the telemetry equipment installed is 357.9 Kg. when dry. During engine operation this rises to 387.4 Kg.

Europa IIIA rocket model and Blue Streak launch pad model

A 1/10 size model of the proposed Europa IIIA rocket (Fig.8) stands some 4m. high against one of the hangar walls. This was presented by HSD in 1972. A further model on display is a 1957, 1/10 size, rocket launch pad for Blue Streak.

Black Arrow Exhibits

Exhibits relating to the Black Arrow Rocket consist of a Gamma BS.625 plumbing prototype for the Black Arrow engine (Fig. 9) and a full-size mock-up of the X-3 satellite (Prospero) (Fig.10).

The Gamma BS.625 engine mock-up on show, made principally from wood to enable pipe runs to be planned, was presented to the Museum by the MoD. It is a representation of the 1964 prototype engine used to power the second stage of the Black Arrow launcher. When installed in Black Arrow, the BS.625 had a dry mass of 167.8 Kg. and provided a thrust of 68.1 KN.

A 1970 engineering prototype of the Prospero satellite is on show. Prospero, 0.712m. in height, 1.145m. in diameter and weighing 66 Kg., was launched by Black Arrow R3 from Woomera at 0409 GMT on 28 October, 1971. Ten and a half minutes later Britain became the sixth country to orbit a satellite with its own rocket, when Prospero entered an

Table 1. Summary of Blue Streak and Black Arrow Launches

Blue Streak		
F1	5. 6.64	Blue Streak only–success.
F2	19.10.64	Blue Streak only–success.
F3	22. 3.65	Blue Streak only–success.
F4	24. 5.66	Dummy 2nd and 3rd stages–success.
F5	15.11.66	Dummy 2nd and 3rd stages–success.
F6/1	4. 8.67	Dummy 3rd stage–French 2nd stage failed.
F6/2	5.12.67	Dummy 3rd stage–French 2nd stage failed.
F7	30.11.68	Orbital attempt–German 3rd stage failed.
F8	3. 7.69	Orbital attempt–German 3rd stage failed.
F9	12. 6.70	Orbital attempt–nose shroud failed to jettison
F11	5.11.71	Only Europe II launch (from Kourou)–broke up in flight due to fault in guidance system.
F12	-	At present at the Kourou Launch site awaiting scrapping together with the research vehicle.
F13	-	On display at the Museum of Flight, East Fortune Airfield.
F14	-	At the Redu Museum, Redu, Belgium.
F15	-	At the Deutsches Museum, Munich, West Germany

Black Arrow		
RO	28. 6.69	Inert 3rd stage–destroyed by RSO after 1 minute.
R1	4. 3.70	Inert 3rd stage–success.
R2	2. 9.70	Orbital attempt with 'Orba' satellite–failed due to loss of first stage pressure.
R3	28.10.71	'Prospero' successfully placed in orbit.
R4		1st stage in storage at Science Museum store, Hayes, West London. 2nd and 3rd stages on display at Science Museum, South Kensington, London.

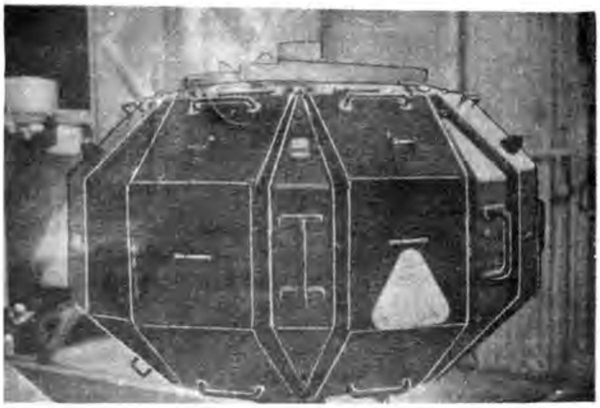


Fig. 10. Engineering prototype of Prospero.

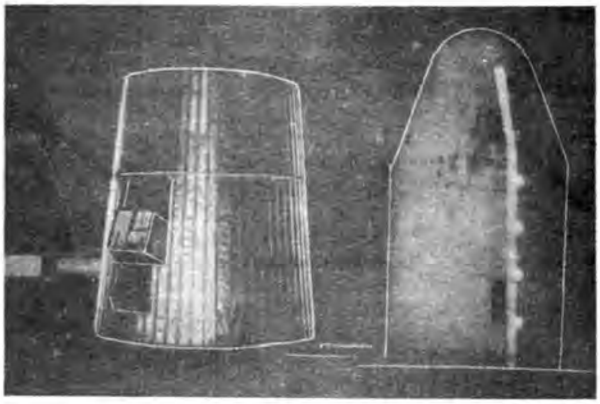


Fig. 11. On the left, the Blue Streak guidance bay. *Right*, a dummy payload shroud.

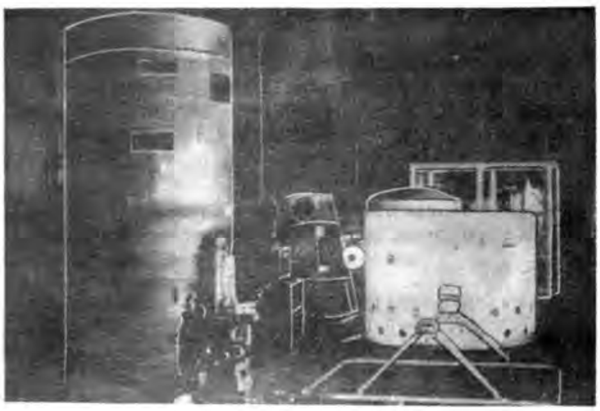


Fig. 12. Four Black Arrow test specimens are just visible. On the group in the foreground are parts of the Black Arrow launch support structure.

orbit of 537 Km x 1582 Km inclined at 82° to the equator. The decision to cancel the launcher programme after Prospero was announced on 29 July 1971, and thus Prospero was the first and last all-British launch.

Rockets and satellites in hanger number IV

Hangar IV contains items not on show to the public, but as some of these are of interest they are detailed below.

Fig.11 is a photograph of the Blue Streak guidance bay, circa. 1960. The section shown comprises the guidance bay as originally designed, which became the transition stage in the Europa vehicle where it mated with the first stage and the French second stage. The vertical stringers and thin external skin are constructed of stainless steel, as opposed to the light alloy structure generally used in aircraft, in order to withstand the kinetic heating that would be experienced in flight.

To the right is a dummy payload shroud. Fig.12 shows four test specimen sections of a Black Arrow rocket. The sections almost make a complete rocket, although parts are badly cracked and corroded. Alongside, to the right, are sections of the Black Arrow launch support structure.

To put the Black Arrow in perspective, its height is only 3 m. greater than the *diameter* of the Apollo-Saturn V first and second stages. Also, its first stage thrust is less than 1% of the Saturn V first stage thrust, i.e. to obtain a thrust equivalent to that of the S-1C, 151 Black Arrows would be needed!

The 12.9 m. high Black Arrow was financed on the very low budget of around £3 million a year. The propellants were kerosene and High Test Peroxide (HTP, an 85-87% stabilised mixture of hydrogen peroxide in water). A first stage thrust of 222.5 KN was provided by the 8 chambers of the BS.606 engine, which was virtually two Gamma 304 engines in harness.

Other items in storage include a ⅛ model of Black Arrow on launching pad and, rather out of place among the British exhibits, a ⅓ model of the Apollo Lunar Module from NASA. Out in the open a Black Knight/Black Arrow launching pad can also be seen.

Table 1 gives details of the Blue Streak and Black Arrow launches.

Conclusion

Because of cold weather the Museum does not open in the winter. It will, however, be open next summer, daily during July and August from 10 am to 4pm, and on certain other dates. Anyone interested in the British contribution to space in the 1960s will find a visit most rewarding. The museum also houses many aircraft from the Spitfire and examples of early jet aircraft to the diminutive Weir W-2 autogiro and a modern hang glider.

Acknowledgement

The author would like to thank the staff of the Museum and the Department of Industry whose assistance made this report possible.

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ASTRONOMICAL NOTEBOOK

By J S Griffith*

SOLAR SYSTEM

The Early Solar System

Study of a portion of the Allende meteorite reinforces the view that the early Solar System was not formed from homogeneous material. It appears that the heterogeneity is due to incomplete mixing of material produced in different nucleosynthetic environments.

The authors of ref. [1] were engaged in an extended search for large, low Mg hibonite samples when they discovered the particular sample whose properties they discuss. The differences between the isotopic abundances indicate that the early Solar System was chemically and isotopically heterogeneous and consisted of many distinct 'reservoirs'. These reservoirs are the result if incomplete mixing between several nucleosynthetic components, each with its own complicated thermal and chemical history.

[1] Lee T, Russell W A, and Wasserburg G J; 'Calcium isotopic anomalies, and the lack of aluminium–26 in an unusual Allende inclusion', *Astrophys. J.* (Letters), 228, L93-L98 (1979).

STARS

Starspots

A theoretical model of a binary system in which one of the components has spots on its surface is used to interpret the light curves of three RS Canum Venaticorum systems.

A good fit with observations is obtained, and the surface activity has many of the properties of solar activity.

The light curves of the RS Canum Venaticorum type binaries are complicated. Solutions for the light curves of three typical systems (RS CVn, SZ Psc, RT Lac) are obtained by assuming the presence of starspots.

The individual spots are considerably smaller than the stellar disk and have lifetimes not substantially different from sunspots. They are dark spots (around 1500K cooler than the atmosphere) and appear to be restricted in both latitude and longitude, not extending to the poles. On the Sun there are preferred longitudes for active regions.

There is direct evidence of magnetic fields in RS CVn systems (flares in HR1099 and UX Am) and indications that magnetic fields are associated with their flaring. For RS CVn the starspot cycle is ~23 years and for RT Lac it is about 30 years.

[1] Eaton, J A and Hall, D S., 'Starspots are the cause of the intrinsic light variations in RS Canum Venaticorum type star.' *Astrophys. J.*, 227, 907-922 (1979).

Gould's Belt

Gould's Belt is an expanding complex of stars, gas and dust outlined visually by its brighter OB stars which lie along a great circle inclined about 18° to the galactic plane. Comparison of optical and radio observations were made.

These observations reveal that about 5×10^7 yr ago a large clump of gas (mass about 10^7 solar masses) in the Carina spiral arm collapsed into a self-gravitating disk. This collapse was triggered by the passage of the spiral shock wave. The compressed disk is either rotating or oscillating around an axis parallel to that of the spiral arm. Further condensation of the gas into smaller clumps was followed by stellar formation (which is still going on). The expansion energy revealed by movement of both Belt gas and stars was provided by the galactic shock which compressed the gas.

[1] Strauss, F M., Poeppel, W G., and Vieira, E R; 'The structure of Gould's Belt', *Astron. and Astrophys.* 71, pp 319-325 (1979).

Highly Compact Binary X-ray Sources

It is proposed that many of the X-ray sources associated with the galactic bulge are accreting neutron stars or black holes (of the order of one solar mass) in ultrashort-period binary systems with very low mass (less than half a solar mass) stellar companions.

About a dozen galactic X-ray sources are believed to be Population I binary systems with a collapsed object (degenerate dwarf, neutron star or black hole) undergoing accretion from a stellar companion. Over 35 other non-extended galactic X-ray sources seem to be associated with the galactic bulge and in ref. [1] are modelled by ultrashort-period binary systems where a neutron star or black hole is accreting material from a low-mass stellar companion. With a late-type dwarf orbiting closely ($\leqslant 10^{\mu}$ cm) around a compact object a mass transfer rate of 10^{-10}solar masses a year can be driven by one or more of three mechanisms. These are decay of the orbit due to gravitational radiation, a self-excited wind, or the evolution of the late-type dwarf remnant of a more massive star. An X-ray luminosity $\geqslant 10^{36}$ erg 5^1 can be generated by the infalling mass. It is noted that due to the small mass of the companion, the probability of an eclipse is small.

[1] Joss, P C and Rappaport S; 'Highly compact binary X-ray sources', *Astron. and Astrophys.* 71, 217-220 (1979).

Discovery of Gravitational Radiation

Measurements of second and third-order relativistic effects in the orbit of the binary pulsar PSR 1913 + 16 have yielded confirmation of the existence of gravitational radiation at the level predicted by general relativity.

Using the 305m radio telescope at Arecibo, Puerto Rico, the authors of ref. [1] analyzed 4.1 years of observations of the binary pulsar 1913 + 16.

Apart from deriving the masses of the pulsar and its companion and detection of geodetic precession of the pulsar spin axis, the observations showed emission of gravitational radiation consistent with that predicted by general relativity, but much smaller than that predicted by other theories of gravity.

The rate of change of orbital period is interpreted as being caused by gravitational radiation carrying energy away from the system.

[1] Taylor J H., Fowler L A., and McCulloch P M; 'Measurement of General relativistic effects in the binary pulsar PSR 1913 + 16', *Nature*, 277, pp 437 - 440 (1979).

Gravitational Radiation

The influence of a gravitational wave on the Doppler shift in the precision electromagnetic tracking of spacecraft is explored. It is also shown that the interaction of gravitation-

* *Lakehead University, Thunder Bay, Ontario, Canada.*

al radiation on a binary system of size small compared to the wavelength of the incident radiation will cause it to make a transition into another orbit with different energy and angular momentum.

If gravitational radiation were to be detected, we would not only have a confirmation of the field concept of gravity and the possibility of testing the predictions of Einstein's theory of gravitation, but we would also have available a new means of observing.

In ref. [1] the effect of gravitational radiation on the Doppler shift of tracking a spacecraft is determined. Then attention is focussed on the effect of gravitational radiation on binary systems (artificial Earth satellite, the lunar orbit and planetary orbits) and, for the Moon, a secular term amounting to 1 cm in distance in 16 years would be produced by gravitational waves from black holes of the order of 10^5 solar masses (core of globular clusters?).

For the Earth-Mars System a change of the order of 20cm after one year should result; and for two Earth satellites the residual shift should be measurable after about 1 week for drag-free satellites.

[1] Mashhoon B., 'On the detection of gravitational radiation by the doppler tracking of spacecraft' *Astrophys. J.*, **227**, 1019-1036 (1979).

GALAXIES AND QUASARS

A Nearby Galaxy!

A previously unknown galaxy at around 1.5 Mpc distance is reported.

While undertaking a high-sensitivity survey at 21m a nearby galaxy was detected in the Orion region. The detection was obtained at one of the sampling points of a survey being conducted with the 91.6m telescope of the National Radio Astronomy Observatory. Subsequent observations were made using the 305m telescope of the Arecibo Observatory while a search for possible companions was made using the 42.6m telescope of the NRAO (ref. [1]).

Although the field is highly obscured by foreground dust, a coincident extended optical feature is discernible in the prints of the National Geographic and Palomar Sky Survey. The low brightness is caused by galactic extinction and in the optical image there is no clear trace of spiral structure or nuclear omission. The hydrogen mass is around 2×10^7 D^2 solar masses where D is the distance in megaparsecs. Using a Hubble constant of 100h km s^{-1} Mpc^{-1} (where h may be ½) the distance is $2.8h^{-1}$ Mpc and its diameter about $10h^{-1}$ kpc. From its radial velocity and location, it is probably not a member of the Local Group.

It is possible that other galaxies may also be hidden in the zone of avoidance (lying in the plane of our Galaxy).

[1] Giovanelli R; 'A nearby galaxy in Orion', *Astrophys. J.*, **227**, L125 - L127 (1979).

The Stripping of Galaxies

The theory that many SO galaxies in clusters are former spirals which have been stripped of their gas by ram-pressure ablation is examined.

Ordinary spirals are almost completely absent from the central regions of dense cluster of galaxies, and SO galaxies are relatively more common in these same regions. The SO/spiral ratio increases with increasing density and increasing X-ray luminosity, suggesting that spirals are stripped by the hot intergalactic medium which is responsible for the X-ray emission.

Theoretical work, summarized in ref. [1], shows that ablation can rapidly transform a spiral galaxy with a substantial gaseous component into an SO galaxy with very little gas. The ablation time scale (10^9 gr) is comparable with the crossing time in a dense cluster and the cessation of active star formation would change the colour of the galaxy from blue to red.

Galaxies which are resistant to ablation are in general those in which there are enough massive objects to keep the mass injection rate sufficiently high at early times. Sweeping becomes effective very soon after collapse, when the galaxies suddenly acquire large velocities relative to the local intergalactic medium. If there is no primordial intergalactic medium, sweeping will not commence until the galaxies have injected sufficient matter by means of galactic winds. At this time those galaxies which are old in terms of their star formation time scales will be more rapidly denuded than the younger ones.

Only those nearby clusters collapsing more recently than 2×10^9 gr ago should contain substantial numbers of blue galaxies.

[1] Gisler G R; 'Gas replenishment rates in galaxies and the stripping of spirals to make SO's.' *Astrophys. J.* **228**, pp 385-393 (1979).

Abell 2218

A weak but complex radio source has been detected in the centre of the cluster of galaxies Abel 2218. The effect of this radio source on the cooling of the microwave background is discussed.

For sometime it has been known that the microwave background is cooled by Compton scattering of electrons in a hot gas in cluster of galaxies. In ref. [1] observations of the cluster Abel 2218 are discussed. These observations were made using the 100m telescope at the Max-Planck-Institut für Radio Astronomieat 2.7 GH_Z using a dual channel correlation radiometer.

The resultant radio map shows that the magnitude of the cooling effect is such that two-dimensional radio mapping of clusters is possible, and in combination with X-ray images would allow the determination of various cluster parameters.

[1] Schallwich D. and Wielebinski R; 'A complex radio source in the center of Abell 2218', *Astron. and Astrophys.* **71**, L15-L16 (1979).

Optical polarization of QSOs

A comparison of the position angle of polarization with the orientation of double radio sources associated with bright QSOs revealed a common orientation. Several possible mechanisms for producing the polarization are discussed.

The lobes of some double radio galaxies are produced by a process in the nucleus that is highly directional and stable over periods of the order of 10^8 years. The existence of such a fundamental axis is confirmed by the results reported in ref [1] where a similar stable polarization in optical wavelengths is found. Linear polarization measurements for approximately 130 QSOs were analysed and it was found that most QSOs are weakly polarized at the 1% level or less.

The existence of the polarization will provide information about the structure of the central source and its surrounding host galaxy.

[1] Stockman H S., Angel J R P., and Miley G K., 'Alignment of the optical polarization with the radio structure of QSOs', *Astrophys. J. Letters*, **227**, L55-L58 (1979).

SATELLITE DIGEST - 131

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed description of the information presented can be found in the January, 1979 issue, p. 41.

Continued from October issue]

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
1979-53A 11397	1979 Jun 10.569 indefinite			35801 35729	36261 35858	1.95 1.92	1448.5 1436.3	ETR Titan 3C DoD/USAF (1)
Cosmos 1106 1979-54A 11399	1979 Jun 12.29 13 days (R) 1979 Jun 25	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	214	236	81.37	89.06	Plesetsk A-2 USSR/USSR
Cosmos 1107 1979-55A 11404	1979 Jun 15.45 14 days (R) 1979 Jun 29	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	197 226 166	302 289 384	72.87 72.86 72.89	89.54 89.69 90.04	Plesetsk A-2 USSR/USSR (2)
Cosmos 1108 1979-56A 11413	1979 Jun 22.29 13 days (R) 1979 Jul 5	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	213	244	81.34	89.13	Plesetsk A-2 USSR/USSR
NOAA 6 1979-57A 11416	1979 Jun 27.661 100 years	irregular box + panel 723	3.7 long 1.9 dia	810	826	98.74	101.32	WTR Atlas F NOAA/NASA (3)
Cosmos 1109 1979-58A 11417	1979 Jun 27.75 12 years?	Cylinder-cone + 6 panels + antennae? 1000?	3.4 long? 1.6 dia?	613 627	40058 39739	62.90 62.89	724.20 718.02	Plesetsk A-2-e USSR/USSR (4)
Progress 7 1979-59A 11421	1979 Jun 28.385 21.71 days 1979 Jul 20.095	Sphere + cone- cylinder 7000	8.0 long 2.2 dia	271 353	346 391	51.63 51.62	90.63 91.61	Tyuratam A-2 USSR/USSR (5)
Cosmos 1110 1979-60A 11425	1979 Jun 28.836 120 years?	Cylinder + paddles? 750?	2 long? 1 dia?	790	812	74.01	100.96	Plesetsk C-1 USSR/USSR
Cosmos 1111 1979-61A 11429	1979 Jun 29.66 15 days (R) 1979 Jul 14	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	255 327	373 413	62.83 62.80	90.81 91.95	Plesetsk A-2 USSR/USSR (6)
Horizont 2 1979-62A 11440	1979 Jul 5.97 indefinite	Cylinder + 2 panels 5000?	5 long 2 dia	36531 35767	36627 35809	0.59 0.79	1476.7 1436.1	Tyuratam D-1-E USSR/USSR (7)
Cosmos 1112 1979-63A 11443	1979 Jul 6.34 8 months?	Ellipsoid + panels? 550?	2 long? 1 dia?	345	544	50.68	93.41	Kapustin Yar C-1 USSR/USSR
Cosmos 1113 1979-64A 11447	1979 Jul 10.38 13 days (R) 1979 Jul 23	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	172 167	318 351	65.01 65.00	89.41 89.70	Plesetsk A-2 USSR/USSR (8)
Cosmos 1114 1979-65A 11449	1979 Jul 11.66 10 years	Cylinder + paddles? 900?	2 long? 1 dia?	504	550	74.04	95.23	Plesetsk C-1 USSR/USSR
Cosmos 1115 1979-66A 11451	1979 Jul 13.35 13 days (R) 1979 Jul 26	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	210 220	235 221	81.35 81.35	89.01 88.97	Plesetsk A-2 USSR/USSR (9)
Cosmos 1116 1979-67A 11457	1979 Jul 20.50 60 years	Cylinder + 2 panels? 2500?	5 long? 1.5 dia?	592	642	81.20	97.10	Plesetsk A-1 USSR/USSR (10)

Supplementary notes:

(1) US military satellite in geostationary orbit above 134° west longitude, purpose undisclosed. Orbital data are at 1979 Jun 12.3 and 25.4.

(2) Orbital data are at 1979 Jun 15.5, Jun 16.6 and Jun 23.5.

(3) Second launch of the latest type of US meteorological satellite. NOAA 6's orbit plane is separated by 90° in longitude from that of it's twin, Tiros 11 (1978-96A), effectively doubling the amount of meteorological data available to the US National Meteorological Center.

(4) Possibly a missile early warning satellite, orbital data are at 1970 Jun 30.0 and 1979 Jul 14.8.

(5) Unmanned supply craft carrying fuel, equipment and supplies to

Lyakhov and Ryumin aboard Salyut 6. Progress 7 docked with Salyut on Jun 30. One of the items carried was a 10m diameter radio telescope which was assembled inside Salyut and then placed outside on Jul 18 after Progress had separated so that the process could be observed by a TV camera aboard the ferry craft. Progress 7 was de-orbited over the Pacific Ocean on July 20, retro-fire occurring at 0157 UT and re-entry approx. 20 minutes later. Orbital data are at 1979 Jun 28.8 and Jun 30.

(6) Orbital data are at 1979 Jun 29.8 and Jul 1.1.

(7) Communications satellite in geostationary orbit above 14° west longitude, the Statsionar 4 location. The satellite arrived on station during Jul 16. Orbital data are at 1979 Jul 10.8 and Jul 26.2.

(8) Orbital data are at 1979 Jul 10.5 and Jul 19.6.

(9) Orbital data are at 1979 Jul 13.5 and Jul 21.4.

(10) Military satellite, possibly an electronic ferret.

Amendments:

1978-120A, Cosmos 1065 decayed at the beginning of 1979 Aug, lifetime 7½ months.

1978-96A, Tiros 11 is similar in description to NOAA 6, see this month's table.

1979-22A, Progress 5, orbital data are at 1979 Mar 12.4, Mar. 13.4 and Mar 14.5.

1979-50A, AMS 4 is an Advanced Meteorological Satellite, similar in appearance to Tiros 11 and NOAA 6. It operates as part of the US military Defence Meteorological Satellite Programme.

MILESTONES/ *Continued from page 434]*

vehicles to orbit Navstar Global Positioning System (GPS-II) satellites to McDonnell Douglas Corporation. Contract is worth $11.5 million. The new upper stage, to be installed on Air Force Atlas boosters, will help to send the satellites into orbits more than 10,000 miles (16,093 km) above the Earth. Designated SGS-II by the Air Force, the upper stage will be powered by a pair of Thiokol Corporation Star solid-propellant rockets arranged in tandem. Each motor is 4 ft (1.22 m) in diameter and about 6 ft (1.82 m) long. First launch is expected in mid-1980. *(The same motor is used in the McDonnell Douglas Payload Assist Module (PAM) spin-stabilised upper stage, which the company is developing to launch unmanned spacecraft to higher orbits from the cargo bay of the NASA Space Shuttle. Ed.).*

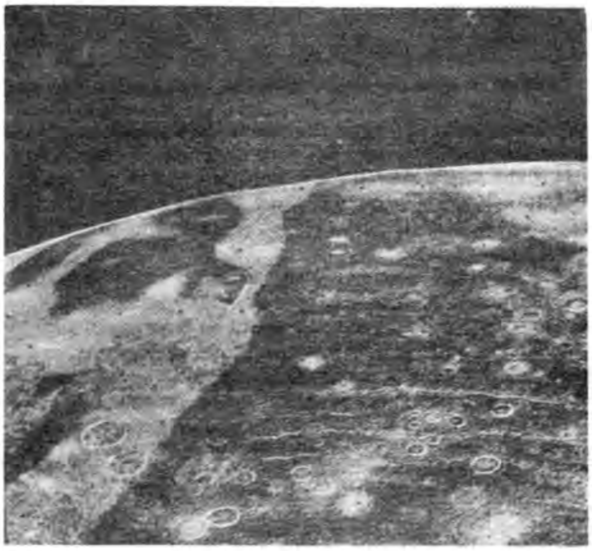
25 An 85 ft (25.9 m) tall, 250 ton, 5½-segment, 120 in (305 cm) diameter, solid-propellant booster for the U.S. Air Force's new-generation launch vehicle, Titan 34D, is test fired at the Facilitues of the Chemical Systems Division (CSD) of United Technologies, Coyote, California. During the two minute burn, the motor which contained 460,000 lb (208,650 kg) of propellant generated 1.3 million lbf of thrust. The motor was fired in a nozzle-up attitude on CSD's ST-9, one of the world's largest vertical test stands. Objectives were to flight-qualify the motor and to test new nozzle and insulation materials.

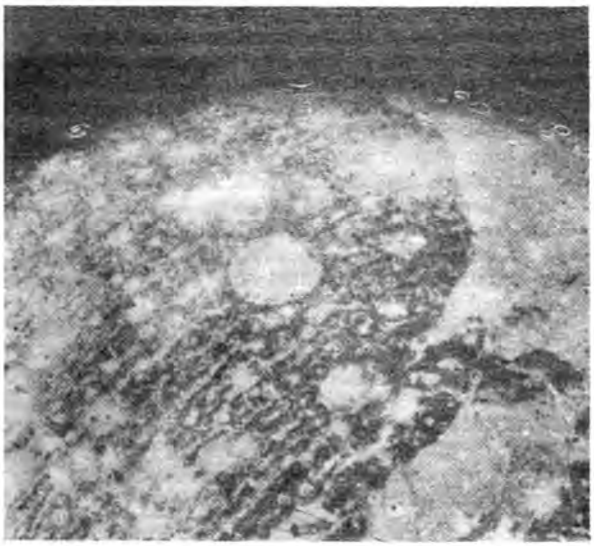
26 Pictures of Saturn taken by Pioneer 11 begin to be better than any taken from Earth.

26 Concern is expressed in Washington that NASA's plans to launch Galileo, the Jupiter orbiter entry probe, could fail to meet optimum January 1983 launch date because of Space Shuttle delays. A delayed launch could mean reducing the scientific payload.

September

1 Pioneer 11 passes at a shallow angle from above Saturn under the rings coming as close as 21,400 km to the cloud tops before moving out from under the rings again. It came as close as 1,900 km to the planet's outermost visible ring believed to consist of rocks, ice and dust. Pictures revealed golden hue of Saturn's banded clouds edged with blue and green below the north pole; also evidence of cloud turbulence similar to that on Jupiter. Evidence was found of a fifth ring beyond known rings and a "bright moving object" which may have been Janus or a previously undiscovered moon.





GANYMEDE, largest of Jupiter's 13 moons,photographed by Voyager 2 from 86,000 miles (138,404 km) (top) and 192,000 miles (309,000 km) on 8 July 1979. They show different views of the largest block of dark heavily cratered terrain seen on the giant body. The bottom image shows objects 3 to 4 miles (4.8 to 6.4 km) across. The light, linear stripes recurring across the dark region resemble the outer rings of the large ring structure on Callisto. Another theory is that these features are not impact-related rings but are internally produced fractures crossing the dark terrain, similar to the grooved bands.

NASA

SOCIETY NEWS

BIS CONTRIBUTIONS TO ORBITAL TECHNIQUE

Generous tribute to the British Interplanetary Society in advancing the idea of spacecraft orbital rendezvous technique is given in the book, *On the Shoulders of Titans–A History of Project Gemini*, recently published by the National Aeronautics and Space Administration.

The authors–Barton C. Hacker and James M. Grimwood –begin by pointing out that the value of rendezvous in orbit first emerged as part of the space station concept, which can be traced through the works of "the Russian pioneers of astronautics–K.E. Tsiolkovskii, Yu. V. Kondratyuk, and F.A. Tsander–and in the writings of their Central European counterparts–Hermann Oberth, Walter Hohmann, Guido von Pirquet, and 'Hermann Noordung'. Their goal was flight to the Moon and planets, but their calculations suggested that chemically powered rockets might lack the power to launch such journeys directly from Earth's surface. If a journey were carried out in stages, however, the problem might be surmounted.

"They proposed using a space station, a stopover point in orbit. Once such a station was built, any number of rockets might be launched to meet it, each bearing its cargo of fuel or supplies to be transferred to the station. When enough had been gathered, fuel and supplies might then be loaded aboard an interplanetary vessel, perhaps itself constructed in orbit, and the real journey to the planets could begin. In effect, the trip would be launched from orbit, the greater part of the velocity needed to escape Earth's gravitational field having been already attained. This concept had been widely accepted in space travel circles by 1929.

"While rendezvous was clearly a key technique in this scheme, it failed to receive any special emphasis. **That changed after 1949, when two members of the British Interplanetary Society pointed out that orbital staging need not depend on first building a space station.** The new concept was called 'orbital technique' or 'orbital operations'. The pieces of an interplanetary vessel might simply be assembled in Earth orbit without troubling to construct a space station, or several rockets might meet in orbit and transfer their fuel to one of their number, which would then embark on the final mission [24]. As Wernher von Braun, later one of NASA's leading advocates of orbital operations, remarked, the space station really amounted to no more than 'a space rigger's hotel'.

"The rapid spread of this idea brought rendezvous into sharp focus. Unlike the space-station concept, to which rendezvous was a sometimes neglected adjunct, orbital operations moved rendezvous to centre stage. The first paper specifically addressed to the problem of 'Establishing Contact Between Orbiting Vehicles' appeared in 1951 [26]. One result was a renewed attention to orbital mechanics, a topic that had languished since the path-breaking work of Walter Hohmann in 1925. By the end of the 1950s, a theoretical framework for rendezvous technique had been largely erected.

"When NASA planners began to grapple with the problem of picking long-range goals for the American space programme, however, they tended to overlook the part rendezvous might play except as it related to space stations . . ."

Later in the book, the authors turn to the concept of lunar orbit rendezvous which is usually attributed to John C. Houbolt of NASA's Langley Research Center.

"The focus of work at Langley also shifted, as Houbolt and his co-workers succumbed to the fascination of a novel application of rendezvous technique, rendezvous in lunar orbit. The essence of the idea was to leave that part of the equipment and fuel needed for the return to Earth in lunar orbit while only a small landing craft descended to the lunar surface, later to rejoin the orbiting mother ship before starting the trip home. In one form or another, this idea had appeared in the work of Oberth, Kondratyuk, and the British Interplanetary Society, to say nothing of later writers. But it reached Langley's rendezvous sub-committee via a brief paper by William H. Michael, Jr., little more than a week after the rendezvous conference at Langley had adjourned [May 1960].

"Michael was part of a small group in the Theoretical Mechanics Division that had been working on trajectories for lunar and planetary missions. The group outlined some of its findings in a pamphlet that made the local rounds near the end of May 1960. Michael's contribution was a brief calculation of the amount of weight that might be saved in a lunar landing mission by parking the return propulsion and part of the spacecraft in lunar orbit. The idea hit Houbolt like revealed truth:

" *'I can still remember the 'back of the envelope' type of calculations I made to check that the scheme resulted in a very substantial saving in Earth boost requirements. Almost spontaneously, it became clear that lunar orbit rendezvous offered a chain reaction simplification on all back efforts; development, testing, manufacturing, erection, count-down, flight operations, etc. . . . All would be simplfied. The thought struck my mind, 'This is fantastic. If there is any idea we have to push, it is this one!! I vowed to dedicate myself to the task'.*

"And dedicate himself he did. Houbolt and a band of disciples embarked on a crusade to convert the rest of NASA to the truth that lunar orbit rendezvous was the quickest and cheapest road to the Moon".

REFERENCES TO BIS PAPERS IN THE NASA HISTORY

24. H.E. Ross, 'Orbital Bases', *JBIS*, 8, January 1949, pp. 1-19. Kenneth W. Gatland, 'Rockets in Circular Orbits', *JBIS*, 8 March 1949, pp. 52-59; letter, Ross to Barton C. Hacker, 9 July 1968; Michael Stoiko, Project Gemini: Step to the Moon (New York, 1963), pp. 34-36.

26. R.A. Smith, 'Establishing Contact Between Orbiting Vehicles', presented at the Second International Congress on Astronautics, London, September 1951, published in *JBIS*, 10 November 1951, pp. 295-299.

NOTE:
This is the second occasion that BIS contributions to spaceflight technique have been acknowledged in recent times. In the May 1979 issue of *Spaceflight*, we published a letter from Mr. Alexander Satin, former Chief Engineer, Air Branch, U.S. Office of Naval Research (ONR) informing us that the 1951 paper "Minimum Satellite Vehicles" by K.W. Gatland, A.M. Kunesch and A.E. Dixon (*JBIS*, 10 November 1951) was used by him "during 1952/54 to direct the first United States Space Project at the Office of Naval Research in Washington, D.C. to an immediate application with available hardware in the United States . . . This eventually became Project 'Orbiter' and was launched as 'Explorer 1' in January 1958."

DR RYCROFT JOINS BRITISH ANTARCTIC SURVEY

Dr. Michael J. Rycroft (BIS Fellow) has been appointed Head of the Atmospheric Division of the British Antarctic Survey. He replaces Dr. W.R. Piggott who retires at the end of the year.

Dr. Rycroft, a long-standing member of the Society, was formerly Head of the Department of Physics, The University of Southampton.

IAF EDUCATION COMMITTEE

We are pleased to announce that Mr. P.J. Conchie (BIS Fellow) and Mr. G.J.N. Smith (BIS Fellow) have been appointed to the Education Committee of the International Astronautical Federation. Messrs Conchie and Smith are Chairman and Vice-Chairman respectively of the Society's Education Committee.

SPACE AFFAIRS

COMMERCIALISING ARIANE

A protocol of agreement was signed at Le Bourget on 12 June 1979 between the main companies involved in the Ariane launcher programme and the Centre National d'Etudes Spatiales (CNES), the programme manager. This marked the first step towards setting up, before the end of the year, a corporation provisionally to be known as TRANSPACE with the object of facilitating the production and commercialisation of Ariane and its derivatives. It will have a corporate capital of about £16.5 million.

The protocol was signed by 29 companies from 10 countries: Belgium, Denmark, France, West Germany, Italy, Netherlands, Spain, Sweden, Switzerland and the United Kingdom. Irish companies are expected to join shortly.

As well as the creation of TRANSPACE, an agreement between the member states of the European Space Agency is being discussed. When this agreement is finalised, an agreement between ESA and TRANSPACE will define procedures of cooperation between the two organisations.

European launcher Ariane. The propellant mock-up at the launch site in Kourou, French Guiana. British Aerospace Dynamics Group's Stevenage Space facility have completed a £1.85 m contract to design, supply and test the hold-down release system for Ariane which is due to be launched for the first time this month.

Centre Nationale d'Etudes Spatiales

SPACE AND THE EUROPEAN PARLIAMENT

With European institutions and Industry making significant progress in many fields of Space science and technology, we are looking towards the European Parliament to strengthen the bonds of member-States in this important endeavour. It was therefore with some disappointment that we noted the response to a Written Question by Lord Bessborough to the Commission of the European Communities (30 September 1977).

Lord Bessborough asked: *Would the Commission list descriptions of the space research and development which each Member State is supporting and the annual amount of support for each project for each year of the project programme?*

In a Supplementary answer [1] given on 16 May 1979, the Commission gave this response:

Further to its answer of 31 October 1977, the Commission wishes to inform the Honourable Member that it does not have at its disposal the descriptions of the space research and development projects which each Member State is undertaking. It has always taken the view that the European Space Agency is responsible, under the terms of the Convention by which it was established (Articles II (c) and II (d) and in order to fulfil its task, for collecting information of the kind required by the Honourable Member.

Hence, the Commission can only quote the amounts contributed by each Member State to the various programmes managed by the European Space Agency as the latter does not obtain any coherent, utilizable information or statistical data from its Member States.

These figures are set out in tables which the Commission is sending direct to the Honourable Member.

[1] A first answer was given on 31 October 1977 (OJ No C **289**, 1. 12. 1977, p.25).

NEW DIRECTOR FOR NASM

Dr. Noel Hinners, NASA Associate Administrator for Space Science, took up his appointment as director of the National Air and Space Museum last spring. Hinners has been with NASA since 1972 and in his previous post he served as deputy director, then director, of lunar programmes. He succeeds Mike Collins (Apollo 11 command module pilot) who directed the Museum from 1972 until 1978 when he was named as undersecretary of the Smithsonian Institution.

MOON BELONGS TO ALL

The United Nations' Committee on the Peaceful Uses of Outer Space—after seven years' work—has drawn up a draft agreement on the Moon. It declares the Moon and its resources to be the common heritage of all mankind, to be used for peaceful purposes only.

The agreement, to be approved by the General Assembly, outlaws the placing or testing of any weapons upon it. The use, or threat of use, of force is barred.

CORRESPONDENCE

Status of Gherman Titov

Sir, Over the past few years there have been rumours that Soviet Cosmonaut Titov had left the Cosmonaut Corps [1].

However, in answer to a question on Radio Moscow's French Service, Titov gave details about the structure and payload of the Progress 5 cargo transport spacecraft [2].

This interview suggests that Titov has probably returned to flight status [3].

1. "No cosmonauts missing?" - James Oberg. Correspondence *Spaceflight*, 20, 4 April 1978, p 159.
2. Radio Moscow's Service France, 18 March 1979.
3. "Soviet Space Shuttle", Brian Harvey. Correspondence *Spaceflight*, 21, 2, February 1979, p 95.

Huntsville Launcher Codes

Sir, My note [1] on the letter designations carried on the sides of Jupiter C and Juno I rockets using the code

HUNTSVIL(L)E
= 12345678 9

ended with the comment: '. . . does not solve the problem of what happened if zero was required in the designation!'

David Harris, PAO at Redstone Arsenal, Huntsville, has supplied me [2] with the answer: since there are only nine available letters in 'Huntsville', an 'X' was used to equal zero. Thus the nosecone test with missile 40 carried 'TX' on its side.

More information has come to light: 12 Jupiter Cs and Juno Is were built and 9 launched, with the launch list as:

Launch	Missile	Letter Code	Launch Date	Comments
1	27	UI	20. 9.56	Jup. C test. UE backup
2	34	NT	15. 5.57	Nose-cone test
3	40	TX	8. 8.57	Nose-cone test
4	29	UE	31. 1.58	Explorer 1
5	26	UV	5. 3.58	Explorer 2. UT backup
6	24	UT	26. 3.58	Explorer 3
7	44	TT	26. 7.58	Explorer 4. TI backup
8	47	TI	24. 8.58	Explorer 5
9	49	TE	22.10.58	Beacon 1

Note that the Explorer 1 launcher, missile 'UE' served as backup in launch 1.

Since I believe it to be of historical importance that the three remaining vehicles are located, efforts are going on in that direction, but it is certain the Jupiter C on display in the National Air and Space Museum in Washington, DC, *is* one of the three. Mr. Harris believes a similar display at the Alabama Space and Rocket Center in Huntsville could also be one. The location of the third Jupiter C is presently unknown.

ANDREW WILSON,
Rotherham, S. Yorkshire.

REFERENCES

1. *Spaceflight* correspondence, p.441, 1978.
2. David G. Harris, private communication, 25 May 1979.

Cosmonauts' Callsigns

Sir, In order to continue the series dealing with the meaning of callsigns used by cosmonauts, may I add the following:

Soyuz 23	RADON	-	Chemical element radon.
Soyuz 24	TEREK	-	Name of river on the Caucasus.
Soyuz 26	TAIMIR	-	Peninsula on the northern part of the Soviet Union.
Soyuz 27	PAMIR	-	The Pamirs means the mountains.

L WINICK
Homewood, Illinois, USA

Mars is Mouthwatering?

Sir, I am not one of those cranks who believe that the Moon is composed of green cheese, but the cover photo of the February 1979 issue (Vol 21, No 2) of *Spaceflight* does tend to support the theory that Mars is composed of white icecream with a topping of chocolate sauce.

T J GRANT
Waddington, Lincolnshire

Carrying the Space 'Torch'

Sir, To the "Carrying the Space 'Torch'" letter of Professor Teofilo M. Tabanera (*Spaceflight*, May 1979, p.240), on the inspiration of the BIS for the founding of the Sociedad Argentina Interplanetaria, let me add another example.

The History Committee of the American Astronautical Society sponsored a "Workshop" at the Goddard Memorial Symposium this past March. It was focused on the founding and twenty-five years of the AAS, 1953-1979. It featured papers, or letters read, by founders, past presidents, editors of the JAS, and others. It made for a remarkable half-day affair, and the paper will be published in a volume in the new History Series of the AAS.

What most of the latter-day members, including myself, learned was that the leaders in the founding of the America Astronautical Society were members of and were inspired b the British Interplanetary Society. Their basic idea was to have a space-dedicated society in the United States, one gaining support from leading professionals, and publishing and holding public meetings to educate a broad spectrum of Americans. Len Carter of BIS tried to dissuade them from starting a new society, as also James Harford of the Americ Rocket Society (originally the American Interplanetary Society), to no avail.

As the BIS looks at its first fifty years, to be emulated is indeed a high form of basic success. To continue to focus thought, stimulatingly, on space affairs broadly considered as the BIS does, has meant that not very many members of AAS gave up their BIS memberships.

EUGENE M. EMME,
Wheaton, Maryland, USA.

Cigarettes and Astronomy

Sir, Congratulations on an outstanding number! (*Spaceflig* May 1979). I was particularly in your 'Space Memorabilia' you mentioned Will's series of cigarette cards issued in 192 called 'Romance of the Heavens'. I was then only 18 years old, an avid collector of all cigarette cards, and this partic series aroused my interest in astronomy.

H. MARTI
Barnard Castle, Co. Durha

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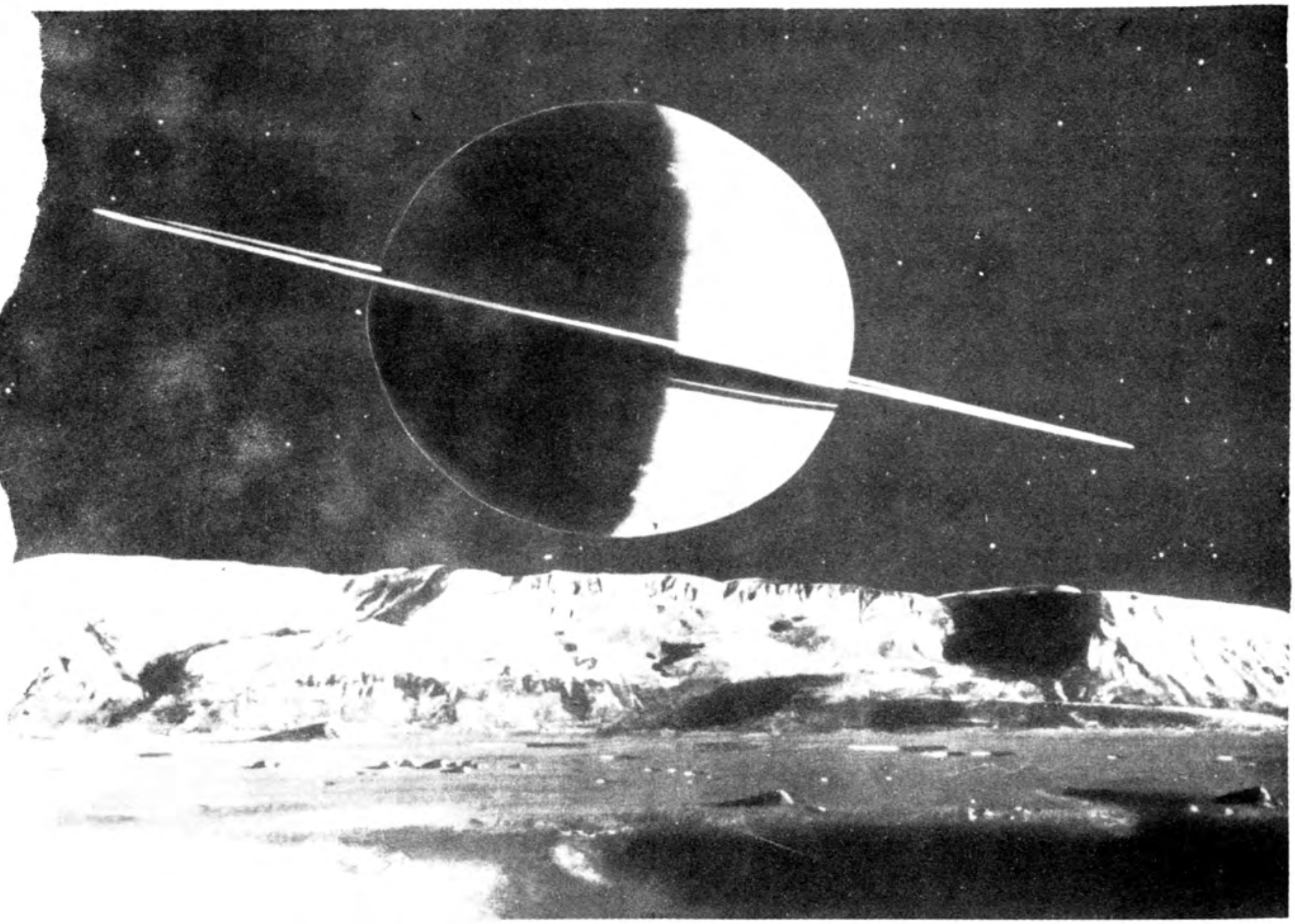

VOLUME 21 No 12 DECEMBER 1979

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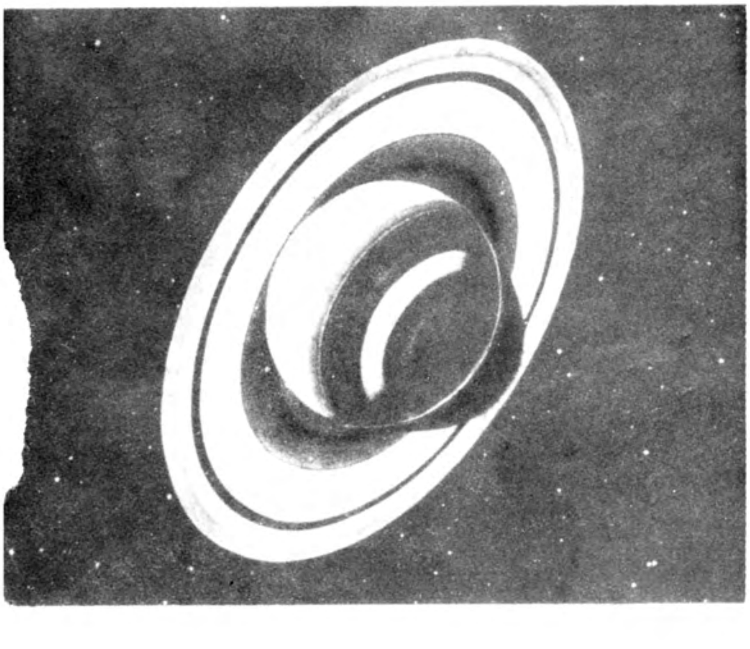

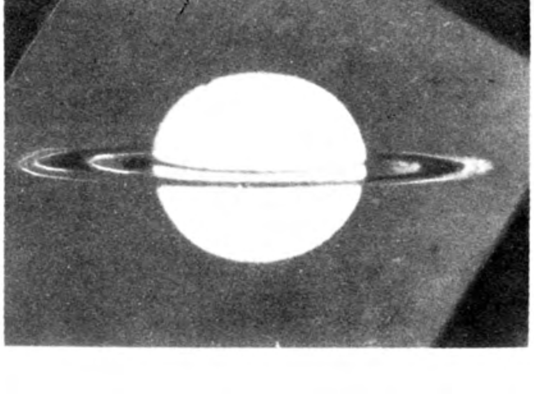

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Editor:
Kenneth W. Gatland, FRAS, FBIS

Assistant Editor:
L. J. Carter, ACIS, FBIS

CONTENTS

COVER

RINGED PLANET. Saturn has been discovered by Pioneer 11 to have an extra ring and two additional gaps have been found in its ring system. New evidence has been obtained for a tenuous outer ring. The spacecraft made a near-equatorial fly-by on 1 September 1979, passing outside the visible rings before swinging far in under them to within about 13,300 miles (21.400 km) of Saturn's banded cloud tops. *Top,* an impression by artist Ron Millar of Saturn as it might appear from the moon Rhea. *Bottom left,* impression by Donald Davis showing the planet from far below the rings on the lighted side. *Right,* the view from Pioneer 11 on 27 August. *NASA*

SPACEFLIGHT

A Publication of The British Interplanetary Society

VOLUME 21 NO. 12 DECEMBER 1979 *Published 15 November 1979*

MILESTONES

September

6 Reported in Paris that France has agreed to Soviet invitation to have a French 'cosmonaut' fly into orbit aboard a Soviet spacecraft. Details are being discussed with officials of the USSR Academy of Sciences and Intercosmos. At least two candidates are expected to be presented for training, and women have not been excluded from the initial selection. Mission is not expected to be flown before 1982.

6 British Aerospace Group reveals that it is producing a design-study for Radio Luxembourg of a direct-broadcast satellite based on design experience obtained with the European Communications Satellite (ECS).

7 Under a modified space programme approved by Japan's Space Council, the Institute of Space and Aeronautical Science (Tokyo University) is to develop a space probe to observe plasma in planetary space, the atmosphere of Venus and Halley's comet. Launch is scheduled in 1985.

12 Final pair of spot beam antenna reflectors for the Intelsat 5 communications satellite have been delivered by British Aerospace Dynamics Group space division at Stevenage under contract to Selenia (Italy). Selenia is the spot beam antenna subcontractor for Ford Aerospace and Communications Corporation. Each Intelsat 5 satellite carries two spot beam reflectors – the east and west antennae, the function of which is to beam signals from the geo-stationary satellite to cover local and closely defined areas in the eastern and western hemispheres, typically western Europe and the north eastern USA.

13 Last qualification test of the first stage of ESA launcher Ariane is made on the test stand of the Société Européenne de Propulsion (SEP) at Vernon, France. Main objectives of test series were: 1. Simulation of a month's wait after filling with propellants, including the full amount of nitrogen tetroxide (the oxidant) for at least a week. 2. Simulation of an aborted launch. This was conducted on 5 September and lasted for 15 seconds. 3. Burn-out on nitrogen tetroxide depletion. The static firing lasted 137 seconds. This test, together with the last engine-qualification test on 10 September, concludes the ground qualification of the first stage.

15 First flight model of Ariane LO1 leaves Le Havre for Cayene, French Guiana. Launch is scheduled between 8 and 18 December.

Prompted by a significant number of Soviet shuttle-related papers at the 30th IAF Congress in Munich – including one which suggested that the Russians may begin 'shuttle operations' in 1980 – press correspondents pressed veteran cosmonaut Major General Georgi Beregovoi for a statement. A Soviet space shuttle was "a logical next step," he agreed. "We don't want to be left behind." Anatoli Filipchenko, who participated in the Apollo-Soyuz Test Project, commented: "We are trying to build a vehicle we don't have to throw away," referring to the costly one-flight-only Soyuz and Progress spacecraft and their launch vehicles.

16 First launch of the new-generation Intelsat 5 communications satellite is expected in February 1980, according to the prime contractor Ford Aerospace and Communications.

17 British Aerospace reveals that a 2Nms reaction wheel assembly designed and built by the Space Division at Stevenage has successfully completed more than 10,000 hours (1.15 years) of continuous operation in a projected seven-year life test. During each 24 hours of continuous running the wheel is driven up to a maximum of 2650 rpm in each direction of rotation.

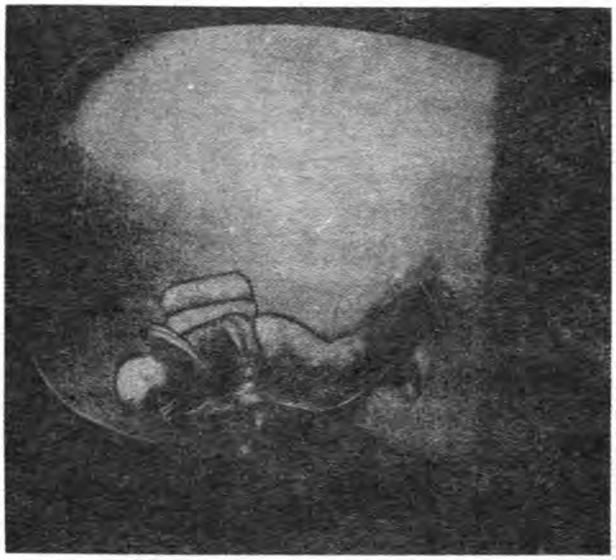
STEPPING OUT

FOURTEEN YEARS OF EXTRAVEHICULAR ACTIVITY

By K. T. Wilson

Introduction

Extravehicular activity (EVA) or 'space walking' has been with us now for 14 years and has without a doubt played a significant part in the success of manned space missions. These years have seen a total of 36 EVA's and 10 stand-up EVA's (SEVA – where the astronaut is only partly outside the spacecraft) performed by 32 astronauts and cosmonauts in Earth orbit, cislunar space and on the lunar surface. Each EVA/SEVA performed is briefly described in this article to show the progress this activity has made since Leonov 'stepped out' in March 1965. The EVA duration times quoted refer to the time from depressurisation to repressurisation of the spacecraft. Actual time outside the spacecraft, where known, is listed in the table.



World's first spacewalk: Alexei Leonov emerges from the inflatable airlock of Voskhod 2 on 18 March 1965.

Novosti Press Agency

Voskhod and Gemini

Alexei Leonov became the first man to walk in space when he left his spacecraft Voskhod 2 *via* an airlock on 18 March 1965. The EVA took place on the second orbit while over the USSR. Leonov, attached to the spacecraft by a tether, floated to a distance of 5 m from the craft but performed no work tasks. Unlike the American Gemini EVA astronauts Leonov had a life support pack on his back during the twenty three minute activity. During entry back into the spacecraft the cosmonaut found that his space suit had 'ballooned' and had to struggle for some minutes before he was able to rejoin his commander Belyayev. Despite this problem the EVA gave confidence that Man would be able to work effectively outside his spacecraft.

Man's second EVA was to take place 10 weeks later by an American astronaut, Edward White, during the Gemini 4 mission. During this and later Gemini missions the EVA astronaut always sat in the right-hand seat of the capsule. He wore a bulky spacesuit while the commander wore only a thin cover layer. This often caused arguments over cabin temperature. White stayed outside the capsule over twice as long as Leonov. The event took place some 193km above the Earth, when White, attached by an umbilical tether, manoeuvred around with the help of a hand-held oxygen powered 'space gun'. The fuel for the manoeuvring unit was exhausted after only three minutes. White remained outside the spacecraft for eight minutes longer than planned and had to be repeatedly told to re-enter the Gemini capsule. Despite stories implying that the EVA was a late inclusion in the flight plan, preparations for it had been going on for some time. However, NASA only qualified the EVA equipment for use in space some 10 days before the mission.

The next planned U.S. EVA was to take place during the Gemini 8 mission when astronaut Scott was to perform experiments outside the spacecraft. This was cancelled due to problems early on in the flight. The next EVA occurred during the Gemini 9 mission. Eugene Cernan, attached by a 7.5 m umbilical tether planned to use a sophisticated astronaut manoeuvring unit (AMU) which was stored at the rear of the Gemini capsule. However, he experienced difficulty in preparing to use the AMU and his space suit began to overheat and his visor mist up. Because of this and poor radio-communications the experiment had to be cancelled. The AMU was eventually tested inside the Skylab space station in 1973.

During the Gemini 10 mission two periods of outside activity were completed by Michael Collins. The first was a SEVA during which the astronaut photographed stars and the Earth using a hand-held camera. This activity was terminated due to a malfunction in the breathing system which affected both astronauts and caused 'a painful burning in the eyes'. During the SEVA Collins reported seeing a very bright object above Gemini. This was thought at first to be Gemini 8's Agena but turned out to be the planet Venus.

The second period of outside activity occurred the next day when Collins, attached by an umbilical tether and using a hand-held manoeuvring unit, 'floated' across to an Agena target. He recovered two micro-meteorite panels but unfortunately lost his camera which had been positioned in a slot on the side of his chest pack. Collins' contact with the Agena was the first time Man had made direct personal contact with another orbiting object.

Gemini 11 also saw two periods of outside activity – an EVA followed by a SEVA. Richard Gordon, the EVA astronaut on this mission encountered problems before he began the EVA. His tinted helmet visor jammed open and it was only after a long struggle that it eventually shut. When the spacecraft hatch was opened Gordon was drenched in sweat, putting a strain on his life support system. During the EVA he recovered a nuclear emulsion experiment from Gemini's adapter section and also unstowed a 30m tether from the Agena to which Gemini had docked earlier. This he fastened to the spacecraft's docking bar and when undocked a gravity-gradient experiment was carried out. Although Gordon rested, over-exertion and the inability of his life support system to remove moisture fast enough forced him back into Gemini earlier than planned. The SEVA performed the following day by Gordon was successful and was devoted to photography of stars and the Earth.

During the final Gemini mission, Gemini 12, astronaut Aldrin spent a record five and a half hours in three periods of outside activity. The first was a SEVA during which Aldrin obtained photographs of stars and the Earth. The second proved to be the most successful Gemini EVA as Aldrin was more successful than previous astronauts in resisting fatigue. During this period of activity Aldrin rested for two minute periods 12 times. This and the improved restraint and handrail arrangements appeared to make his outside work relatively easy. His work tasks included the

loosening and tightening of bolts at special work sites, the exposure of a micro-meteorite collector plate and the attachment of a 30m tether to an Agena for a gravity-gradient experiment. Aldrin also wiped clean Lovell's hatch window. The final period of outside activity was a SEVA during which Aldrin photographed the Earth and took ultraviolet pictures of stars and planets. Gemini 12 was an unqualified success. Aldrin proved that, with suitable rest periods, Man could work outside the spacecraft successfully.

At the end of the Gemini programme American astronauts had spent twelve hours and twenty three minutes in outside activity compared with only twenty three minutes by one Soviet cosmonaut.

Soyuz and Apollo

On 16 January 1969 after a gap of nearly four years, the second Soviet EVA took place. It occurred during the joint Soyuz 4 – Soyuz 5 mission, the first docking of two manned spacecraft. The EVA involved a transfer of two of the three Soyuz 5 cosmonauts to Soyuz 4 which contained only one cosmonaut. Khrunov and Yeliseyev in Soyuz 5 donned a new type of EVA space suit and egressed into space through a hatch located on Soyuz 5's orbital module. The cosmonauts, with life support equipment attached to their legs, installed and dismantled camera supports, handrails and television equipment. Following these tasks the two men entered the orbital module of Soyuz 4 and then into the descent module where cosmonaut Shatalov was waiting. The transfer, which lasted an hour, had been assisted by handrails mounted on the outside of both spacecraft. This was to be the last Soviet EVA for nearly nine years.

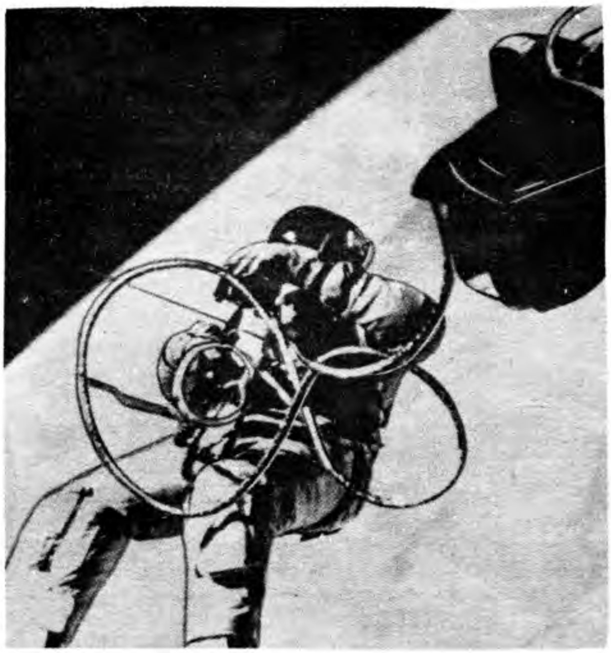
The second EVA of 1969 was performed by the American Apollo astronaut Russell Schweickart during the Apollo 9 mission. This, the first Apollo EVA, was planned to be a two hour event but Schweickart suffered nausea and vomiting and so the full EVA was cancelled and a shorter one took its place. During the EVA Schweickart positioned himself on the 'porch' of the docked Lunar Module (LM) where he took photographs and tested the new portable life support system (PLSS) which was to be used on the Moon later that year. The planned EVA transfer from the LM to the Command Module (CM) was cancelled. At the same time as Schweickart's EVA, the Command Module Pilot (CMP), David Scott, performed a SEVA from the CM hatch. He photographed Schweickart's activities and also retrieved material samples from the CM skin.

The next EVA, four and a half months after Apollo 9's, took place at Tranquillity Base on the lunar surface during the Apollo 11 mission. Neil Armstrong began a two and a half hour EVA at 03.56 BST on 21 July 1969 when he backed down the LM ladder to become the first man to set foot on the Moon. He was followed by Edwin Aldrin eighteen minutes later. Both astronauts explored the lunar surface surrounding their spacecraft, took photographs, set up experiments and collected rock and soil samples.

Apollo 12, the next American lunar landing mission saw two lunar surface EVA's by astronauts Conrad and Bean. During the first EVA the astronauts set up the Apollo Lunar Surface Experiments Package (ALSEP), took photographs and collected rock and soil samples. The second EVA which occurred the following day included a walk across to an unmanned Surveyor spacecraft which had landed 31 months earlier. Conrad became the first man to fall on the Moon, but due to the one-sixth gravity there was not much danger to the astronaut.

Astronauts Alan Shepard and Edgar Mitchell were the next to perform EVA, this time during the Apollo 14 mission. Two EVA's were performed in the Fra Mauro region of the Moon, an upland area which had originally been Apollo 13's target. Shepard, the first American in space, became the fifth man to step on the Moon and was soon accompanied on the surface by Mitchell who was on his first space flight. The first EVA was devoted to the setting up of the second ALSEP, photography and rock and soil sampling in the vicinity of the LM. The following day on the second EVA the astronauts set of on a 1.6km trip to Cone Crater. However, the walk proved to be tiring and to add to this problem the astronauts could not find the crater rim. During the two EVA's Shepard and Mitchell used a Mobile Equipment Transporter (MET) to carry equipment and rock samples.

The next lunar mission, Apollo 15, was the first of the 'J' series and produced no fewer than four EVA's and two SEVA's. The first period of outside activity was a lunar surface SEVA by David Scott, the mission commander. Soon after landing he opened the top hatch of the LM and photographed the surrounding terrain. This was followed the next day by the first of three lunar surface EVA's during which Scott and Irwin, the Lunar Module Pilot (LMP), deployed the Lunar Roving Vehicle (LRV) and set up the third ALSEP science station. A trip to the edge of nearby Hadley Rille was also successfully completed. On EVA 2 the next day the astronauts drove to the foothills of the Apennine Mountains where rock and soil samples were collected. The third EVA was also devoted to geological investigation of the lunar surface in the vicinity of the landing site. Three days later the fourth EVA took place, this time in cislunar space after the Trans-Earth Injection (TEI) at a distance of 321,870km from the Earth. Worden, the CMP, spacewalked from the CM to the Scientific Instrument Module (SIMBAY) to retrieve film cannisters. Special hand grips and foot restraints were positioned around the SIMBAY to aid the astronaut in his work. Worden was assisted by Irwin who performed a SEVA from the CM hatch. This, the first deep space EVA, was the first inflight EVA made for a practical working purpose. During this cislunar EVA and those during Apollo 16 and Apollo 17 the CMP wore the commander's space suit because only two suits were carried with full EVA capability on these missions.



Astronaut Ed White moves away from the Gemini 4 spacecraft as his umbilical unreels from a black bag in which it was stowed until he emerged. Photo by fellow astronaut James McDivitt.

NASA

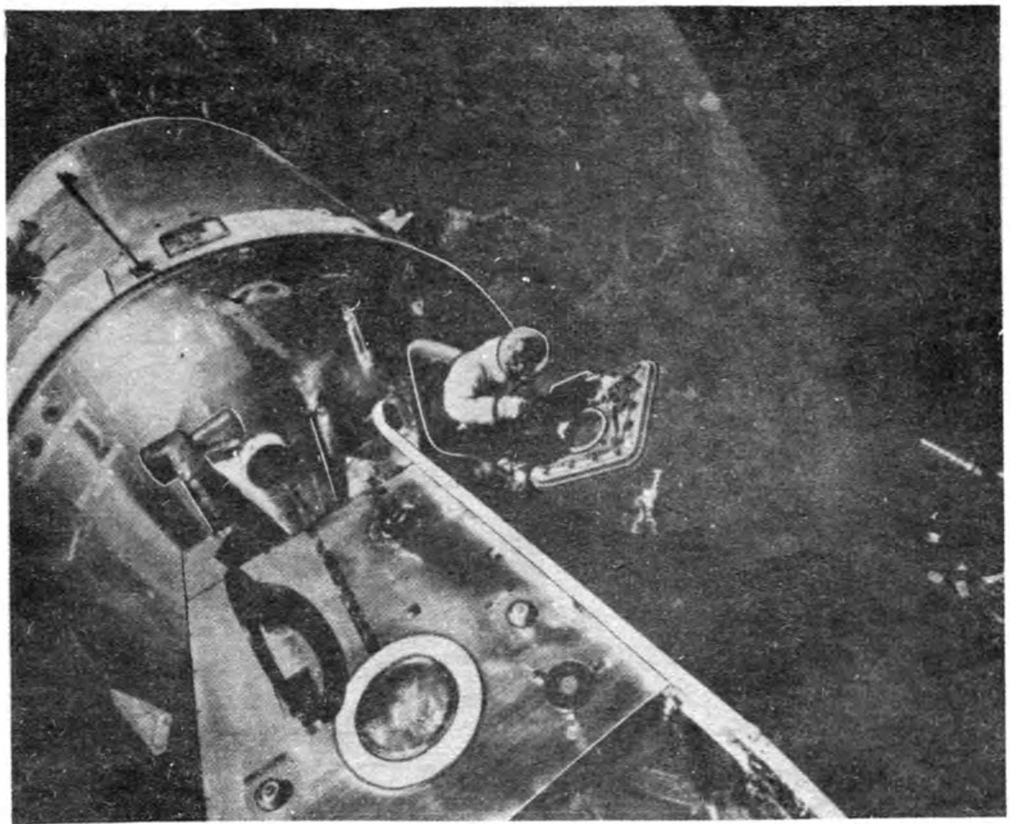
John Young and Charles Duke began the ninth lunar surface EVA on 21 April 1972 during the Apollo 16 mission. As usual the first EVA was devoted to deploying the LRV, setting up the fourth ALSEP and rock and soil sampling. The second EVA was taken up with a 4.1 km drive to Stone Mountain where a geological investigation was carried out and the third EVA was devoted to the exploration of North Ray Crater some 5 km from the LM. At the end of the EVA Duke fell on his back during a high jumping competition. Luckily he escaped without injury. The final EVA of the mission by the CMP Thomas Mattingly took place after TEI at a distance of 274,000 km from Earth when he spacewalked to the SIMBAY to retrieve film cassettes. Duke assisted from the CM hatch during a SEVA.

Table of Extravehicular Activity – 1965/1978.

Mission	EVA Date	EVA Astronaut(s)	Type of Activity	Duration of Activity (hrs.min.)
Voskhod 2	18.3.65	Leonov	EVA	0:23 (0:10)
Gemini 4	3.6.65	White	EVA	0:36 (0:21)
Gemini 9	5.6.66	Cernan	EVA	2:08
Gemini 10	19.7.66	Collins	SEVA	0:49
Gemini 10	20.7.66	Collins	EVA	0:39 (0:25)
Gemini 11	13.9.66	Gordon	EVA	0:33
Gemini 11	14.9.66	Gordon	SEVA	2:08
Gemini 12	12.11.66	Aldrin	SEVA	2:29
Gemini 12	13.11.66	Aldrin	EVA	2:09
Gemini 12	14.11.66	Aldrin	SEVA	0:52
Soyuz 4/5	16.1.69	Khrunov-Yeliseyev	EVA	1:00 (0:37)
Apollo 9	6.3.69	Schweikart	EVA	0:37
Apollo 9	6.3.69	Scott	SEVA	0:46
Apollo 11	21.7.69	Armstrong-Aldrin	EVA (LS)	2:31 (2:14,1:33)
Apollo 12	19.11.69	Conrad-Bean	EVA (LS) 1	3:56 (3:56,3:30)
Apollo 12	20.11.69	Conrad-Bean	EVA (LS) 2	3:49 (3:49,3:20)
Apollo 14	5.2.71	Shepard-Mitchell	EVA (LS) 1	4:48 (4:32,4:20)
Apollo 14	6.2.71	Shepard-Mitchell	EVA (LS) 2	4:35 (4:22,4:05)
Apollo 15	30.7.71	Scott	SEVA (LS)	0:33
Apollo 15	31.7.71	Scott-Irwin	EVA (LS) 1	6:33 (6:14,6:02)
Apollo 15	1.8.71	Scott-Irwin	EVA (LS) 2	7:12 (6:55,6:50)
Apollo 15	2.8.71	Scott-Irwin	EVA (LS) 3	4:50 (4:27,4:19)
Apollo 15	5.8.71	Worden	EVA (CL)	0:38 (0:16)
Apollo 15	5.8.71	Irwin	SEVA (CL)	0:38
Apollo 16	21.4.72	Young-Duke	EVA (LS) 1	7:11 (7:00,6:43)
Apollo 16	22.4.72	Young-Duke	EVA (LS) 2	7:23
Apollo 16	23.4.72	Young-Duke	EVA (LS) 3	5:40 (5:30,5:19)
Apollo 16	25.4.72	Mattingly	EVA (CL)	1:13
Apollo 16	25.4.72	Duke	SEVA (CL)	1:13
Apollo 17	11.12.72	Cernan-Schmitt	EVA (LS) 1	7:12
Apollo 17	12.12.72	Cernan-Schmitt	EVA (LS) 2	7:37
Apollo 17	13.12.72	Cernan-Schmitt	EVA (LS) 3	7:16
Apollo 17	17.12.72	Evans	EVA (CL)	1:06 (0:45)
Apollo 17	17.12.72	Schmitt	SEVA (CL)	1:06
Skylab 2	25.5.73	Weitz	SEVA	1:15 (0:37)
Skylab 2	7.6.73	Conrad-Kerwin	EVA	3:30
Skylab 2	19.6.73	Conrad-Weitz	EVA	1:44
Skylab 3	6.8.73	Garriott-Lousma	EVA	6:31
Skylab 3	24.8.73	Garriott-Lousma	EVA	4:30
Skylab 3	22.9.73	Bean-Garriott	EVA	2:45
Skylab 4	22.11.73	Gibson-Pogue	EVA	6:33
Skylab 4	25.12.73	Carr-Pogue	EVA	7:01
Skylab 4	29.12.73	Carr-Gibson	EVA	3:28
Skylab 4	3.2.74	Carr-Gibson	EVA	5:19
Soyuz 26/Salyut 6	20.12.77	Grechko	EVA	1:28 (0:20)
Soyuz 29/Salyut 6	29.7.78	Kovalyonok-Ivanchenkov	EVA	2:05

NOTES

1. Duration times are from capsule depressurisation to repressurisation.
2. Actual time outside the spacecraft for each astronaut, where known, is in brackets after the duration time.
3. LS – Lunar surface.
4. CL – Cislunar space.



Apollo 9 astronaut David Scott as photographed during extra-vehicular activity by Russell Schweickart from the porch of the Lunar Module. Scott is standing in the open hatch of the Command Module, the two modules having being docked together. Land area visible includes the Mississippi River Valley in the central United States.
NASA

Apollo 17, the final lunar landing mission included in its crew the first qualified geologist to visit the Moon, Harrison Schmitt. Along with Cernan, the mission commander, they landed their LM in the Taurus/Littrow region of the Moon. Three lunar surface EVA's were completed, the first as usual taken up with LRV and ALSEP deployment as well as geological investigation of the surface near the landing site. The second EVA, the longest to date, 7 hours 37 minutes 21 seconds, included a drive across 'the valley' to South Massif. The third and final EVA on the lunar surface was again devoted to geological investigation, this time in the vicinity of North Massif. Evans, the CMP, completed the final EVA of the mission during the return flight at a distance of 290,000km from Earth. He successfully retrieved camera cassettes from the SIMBAY and was aided in this task by Schmitt who stood in the CM hatch to collect the cassettes. Cernan, Apollo 17's commander, still holds the world record: twenty four hours and thirteen minutes during four EVA's.

At the end of the Apollo programme the American total for outside activity had reached one hundred and eighty one hours and nineteen minutes of which one hundred and sixty one hours and thirty nine minutes had been taken up with lunar surface exploration. The Soviet Union on the other hand which had performed only one EVA during this period lagged well behind with only two hours and twenty three minutes of outside activity to its credit.

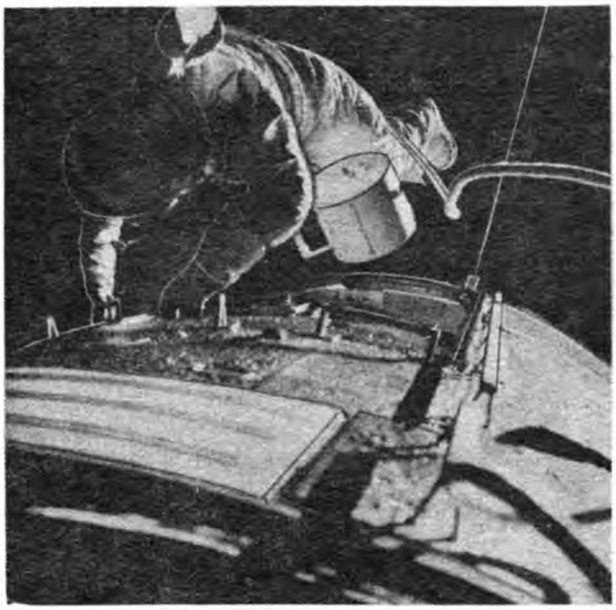
Skylab and Salyut

Skylab 1, America's first space station was launched on 14 May 1973 and was visited by nine astronauts during three missions. Outside activity was performed on each mission, the first period being a SEVA by Skylab 2 astronaut Paul Weitz. He stood in the CM hatch with astronaut Kerwin holding his legs and the mission commander Conrad manoeuvring the spacecraft around the space station. During the SEVA, Weitz, using wire cutters and a long pole tried to free a jammed solar panel which was trapped by an aluminium strap. His attempt to free the panel however was unsuccessful. The second period of outside activity occurred on the fourteenth day of the mission when Conrad and Kerwin managed to free the jammed solar panel during an EVA. A handrail was assembled to help the two astronauts in this activity. Kerwin fixed two faulty telescope shutters during this EVA. The third and final EVA of the mission was performed by Conrad and Weitz. They retrieved six cannisters of film from the Apollo Telescope Mount (ATM) and installed new film for instruments that would operate automatically until the second crew arrived. Conrad also fixed a battery regulator relay by tapping it with a hammer.

The next EVA's were performed by the Skylab 3 crew, Bean, Garriott and Lousma. The first, a six and a half hour stint by Garriott and Lousma, saw the replacement of the original sunshade deployed by the previous crew from Skylab's interior with a more effective twin-pole shade. This further reduced the workshop's temperature. The two astronauts also installed solar telescope film and searched without success for clues to the problems affecting the CM thrusters. The second EVA of the mission by the same astronauts included the installation of six new gyroscopes to the nine gyroscope system that maintained Skylab's proper position. ATM film was once again changed. The final EVA saw the commander Alan Bean accompany Garriott outside the workshop to retrieve and replace solar telescope film. The film taken from the ATM contained over 77,000 pictures of the Sun.

During the final Skylab mission, four EVA's were performed by astronauts Carr, Gibson and Pogue who stayed in space for a U.S. record of eighty four days. The first EVA was performed on a holiday, Thanksgiving Day, when Gibson and Pogue spent six and a half hours outside Skylab. Their most difficult task was to repair a jammed antenna. This involved the removal of six screws in an area which lacked handgrips and restraining devices.

The second EVA also occurred on a holiday, Christmas Day, when Carr and Pogue conducted a record seven hours one minute inflight EVA during which Comet Kohoutek was photographed before it passed behind the Sun. The astronauts also rectified a filter fault in the ATM's X-ray Spectrographic Telescope and retrieved film cassettes and other



Apollo 17. During the homeward run command module pilot Ronald E. Evans retrieves film and other experiment material from the service module.

NASA

equipment. The third EVA of the mission was performed only four days later by Carr and Gibson and was devoted to Kohoutek photography as the comet moved away from the Sun.

The fourth and final EVA of the mission, the last planned EVA by American astronauts this decade, occurred on 3 February 1974 during the last few days of the mission. Carr and Gibson teamed up once again to retrieve the last of the ATM film and material samples for post-flight analysis of the effects of the space environment. Total Skylab EVA/SEVA time was eighty three hours and fifty seven minutes bringing the American total for outside activity to two hundred and sixty five hours and sixteen minutes, a record unlikely to be surpassed for many years.

During the Skylab programme the Soviet Union had been continuing with their Soyuz flights, but it was not until December 1977 that the third Soviet EVA was performed. During the Soyuz 26/Salyut 6 mission, cosmonaut Grechko left Salyut through the docking unit hatch and inspected Salyut's forward docking port for damage after the failure of Soyuz 25's docking attempt. No damage was found and the docking port has since been used without any problem. Grechko wore a new EVA suit and carried special tools with him. Romanenko, his companion on this mission, remained in the depressurised transfer compartment throughout the EVA.

Just over seven months later the next EVA took place, this time during the Soyuz 29/Salyut 6 mission. Cosmonauts Kovalyonok and Ivanchenkov spent over two hours completing tasks on the exterior of Salyut. They egressed into space through the space station's side hatch. A colour television camera was set up to record the two cosmonauts retrieving radiation meters, material samples and a micro-meteorite detector. New apparatus to register space radiation was also installed. During the EVA Salyut 6 passed into Earth's shadow and the cosmonauts worked under flood lights mounted on the exterior of the space station. This crew at present holds the duration record for time in space, one hundred and thirty nine days. At the conclusion of this mission Soviet cosmonauts had spent a total of eight hours and one minute in extravehicular activity.

Conclusion

The progress made in EVA since the days of Voskhod and Gemini has been considerable. Since Leonov 'stepped out' fourteen years ago Man has accumulated two hundred and seventy three hours and seventeen minutes of extra-vehicular activity, the majority of this being by American space crews. However, recent indications point towards an increase in Soviet EVA's. With the coming of the Space Shuttle in late 1979 or early 1980 and the continuation of the successful Soyuz/Salyut flights EVA is sure to continue.

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UK BUILDS SPACE SLEDGE

Work began on 2 May 1979 on the construction of the Space Sledge. The sledge to be carried in the Life Sciences module of Spacelab consists of a chair which can move along a guide rail by means of a DC electric motor, writes Geoffrey Lindop.

The Space Sledge will help in physiological experiments performed in Spacelab. The chair can be orientated in any one of three mutually orthogonal directions with respect to its linear motion.

Marshall of Cambridge (Engineering) Ltd have been contracted by ESA to provide the mechanical subsystem, a contract which they won in competition with four other companies. This is the first time Marshall of Cambridge have built anything for the Space Industry, although it is a natural extension of the work they perform in the aircraft industry. Mr. Gates, the Chief Engineer, said that Spacelab was intended to be used on 50 flights, as opposed to the conventional one-off space shot. This posed problems of fatigue similar to those encountered in the aircraft industry. A technical report about fatigue in aerospace systems was prepared by Marshall and submitted to ESA last year. Mr. Gates went on to say that the specification for space systems was somewhat higher than for general engineering and the current project demonstrated the integrity of his company to compete in work of this high standard.

The Bell Telephone Manufacturing Company of Belgium is the other contractor involved having been nominated to provide the electrical sub-system for the Sledge. System Design Phase was completed in August 1979. A Crew Training Model will be delivered to SPICE* in mid-August 1980, and the Protoflight Model in October 1980.

All Sledge experiments with the Test Subject in the Sledge chair are controlled by the Test Operator in the aft-end of Spacelab. Control from the ground, or from the Orbiter aft-deck can only be by way of voice communication with the Test Operator. The Test Operator and the Test Subject can independently stop the Sledge at any time. A crushable end-stop ensures a smooth and safe stop at the end of the runway in case of an unexpected malfunction.

* *SPICE = Spacelab Payload Integration & Co-ordination in Europe.*

THE ORIGINS OF THE U.S. SPACE SHUTTLE - 2

By Curtis Peebles

Continued from the November issue]

Introduction

By 1964, the Space Age was entering its seventh year. The Mercury Program had been completed the previous year and the Gemini flights were still a year and a half away. The first unmanned probes to the Moon, and Venus had been launched. The X-15 had made several brief flights into space.

With the end of the Dyna-Soar programme, both NASA and the U.S. Air Force, encouraged by the success of the M2-F1, had become interested in the possibilities of lifting bodies. They offered a good compromise between ballistic and winged craft. They were lighter than a winged vehicle (one of the factors which doomed the Dyna-Soar) and simplified structural and heating problems [1]. On the negative side, a lifting body had a lesser cross-range capacity and a steeper re-entry angle [2].

The Lifting Bodies

In the spring of 1964, NASA requested bids for the construction of two different lifting bodies. The purpose was for supersonic flight tests extending the M2-F1 data. North American Aviation, Northrop, General Dynamics, United Technology Center and Ryan responded. In April, Northrop's, Nor-air Division was selected.

The first of the two designs—a Northrop designed and built aircraft—was the M2-F2. It was essentially a refined rocket-powered version of the M2-F1. The other was the HL-10. It was a NASA design based on work undertaken by the Langley Research Center. HL stood for Horizontal Landing and was the tenth concept to be investigated at Langley. The configuration—flat on the underside and rounded on top—was the reverse of the M2-F2.

To minimize cost and speed construction of the two vehicles, much of the hardware was built from verbal instructions. Existing components from other aircraft—(F-106 ejector seats, T-38 wheels, etc.) were incorporated, jigs and fixtures were avoided and because the craft did not have to withstand re-entry, the craft was skinned in aluminium alloy [3].

In August, the Air Force announced the formal go-ahead for the START (Spacecraft Technology and Advanced Re-entry Program). The contractor, Martin Marietta, had six years experience in lifting body research. But, still, the programme got off to a shaky start. Wind tunnel test data had indicated the selected shape was unstable at low speed and unsuitable for manned flight [4]. The final shape was a flat bottomed arrowhead with two fins jutting from the sides.

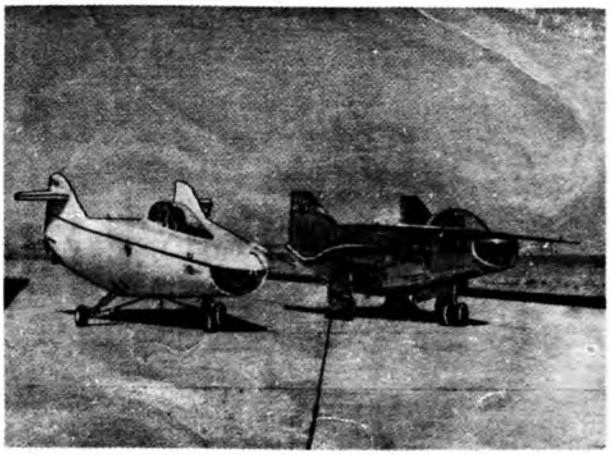
Once the configuration was set, work was begun on the sub-scale, sub-orbital X-23, the manned rocket powered X-24 and the jet powered SV-5J trainer.*

On 14 June, 1965, the first of the three designs, the M2-F2 was rolled out and turned over to NASA for wind tunnel testings [5]. The HL-10, second of the Northrop lifting bodies, was delivered on 18 January 1966.

Glide Flights of the M2-F2 and HL-10

A programme of glide flights, for the M2-F2, was planned lasting over a year. The first captive flight, under the wing of a B-52, was made 23 March, 1966 for systems check out. July 12th, Milton O. Thompson made the first glide flight in the M2-F2. The drop took place at 45,000 ft (13,720 metres); the touch down speed was 200 mph (322 kph).

Over the next two months, Thompson would make a total of five glide flights for the purpose of evaluating vehicle systems, conducting stability and control tests as well as trim and performance. Thompson left the programme to become director of research projects at the NASA Flight Research Center.



LIFTING BODIES. The original M2-F1 (left) with the M2-F2.
NASA

In September and October, 1966, NASA test pilot, Bruce Peterson, and Air Force test pilots, Lt. Colonel Donald Sorlie and Captain Jerald R. Gentry made glide check-out flights. November 21st, Gentry made the 14th and last glide flight before the XLR-11 rocket engine was installed [6].

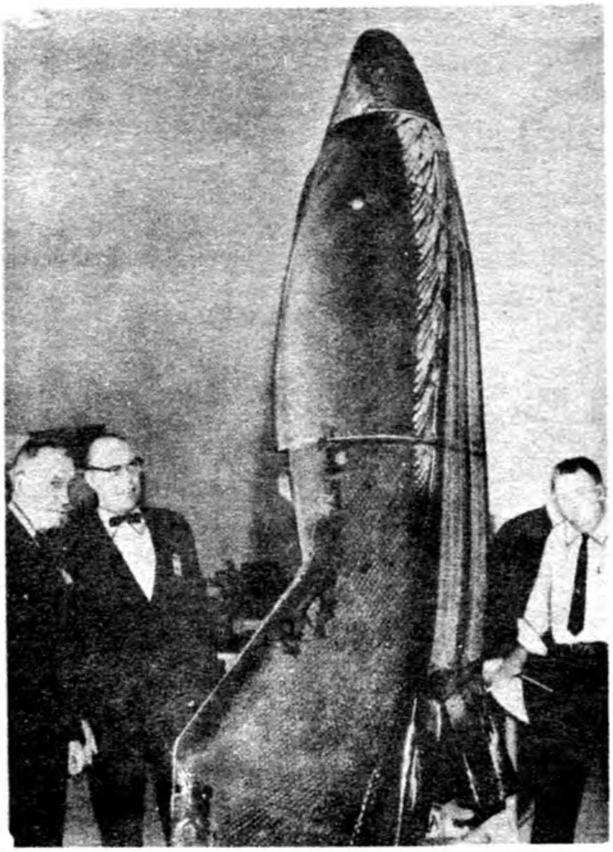
Shortly after the M2-F2 was grounded, the HL-10 had been made ready for its first flight. The first glide flight was for design and system check-out. It came on 22 December, 1966. Bruce Peterson found the HL-10 deficient in lateral control. During turns the aileron effectiveness dropped to near zero. It had, as well, severe environmental control systems problems. It was grounded pending wind tunnel tests to solve the problem. The flaw was discovered to be in the vertical tail fin, so changes were made to improve airflow over the control surfaces [7]. The HL-10 would not fly again for 15 months.

X-23, Lifting Bodies into Space

The third lifting body was also ready for flight in late 1966. During the X-23's development, approximately 50 low speed flights were made using a model before re-entry vehicle construction was begun. The ASSET programme had tested refractory materials but it did not have the capacity to manoeuvre during re-entry. This was the X-23's purpose. The vehicle was covered with a Martin Marietta developed ablative heat shield material called 3560H. The nose and control fins were of moulded carbon phenolic material. It was controlled by nitrogen thrusters and hydraulically operated flaps [8]. By differential movement of these flaps, it was able to change its flight path. It had a cross-range capacity of 800 miles (1,290 km) to the right or left of the flight center line and could land anywhere within a footprint 3,636 miles (5,855 km) long [9]. The vehicle was 7ft long and 4ft wide (2.13 and 1.22 metres) and weighed 894 lb. (406.36 kg.) Its hypersonic L/D was 1.3 to 1.

The SLV-3 Atlas launch vehicle would propel it to an entry velocity of 26,000 fps (7,927 mps)—nearly orbital velocity. For recovery, it carried a Drogue chute in the tail and the main parachute in the upper surface. If the air pick-up by HC-130 failed, a flotation bag would keep it from sinking.

Company designations were: SV-5D, SV-5P, SV-5J



The X-23 displays the effect of near orbital speed re-entry. This vehicle checked out the high speed aerodynamics of a lifting body.

U. S. Air Force

The first launch came on 21 December, 1966 out of Vandenberg AFB. The X-23 separated from the Atlas and glided toward the recovery zone near Kwajalein Island.

The first flight was to check out the aerodynamic characteristics of the shape, the heat shield performance, guidance, on board instrumentation, flight systems and recovery systems. No cross-range manoeuvring was planned; only pitch manoeuvres were made by moving the flaps in unison; telemetry was radioed back. High over the waiting recovery forces, the parachute malfunctioned and the X-23 fell into the Pacific [10].

The next flight was launched on 5 March, 1967. During re-entry, the flaps extended into the slipstream. The X-23 banked away from its original path. When it was 568 miles (915 km) away, it reversed and returned to its original course. The parachute opened and it splashed down. But as the recovery forces rushed toward it, the flotation gear was lost and it sank [11].

The third launch took place on 19 April, 1967. Once more the vehicle banked away from a direct course. When it reached 800 miles (1,290 km), it reversed until it was 800 miles to the other side of its original trajectory; then returned to its original course. As the glider descended under its parachute, an HC-130 recovery aircraft spotted it and made a successful mid-air recovery [12]. So successful were these flights that the fourth mission was cancelled as unnecessary.

The third X-23 was shown to newsmen at the Pentagon on 23 May. The programme's accomplishments included proving that an aerodynamically controlled vehicle could re-enter the atmosphere and manoeuvre to a landing point of its choosing. Ablative coatings, the guidance and flap systems were proven and ground-based terminal guidance was demonstrated [13].

The End of the M2-F2

The XLR-11 engine installation was completed in the spring of 1967 and glide flights were resumed in May. During the early flights, it was found that, like the M2-F1, the M2-F2 had a tendency to Dutch roll. This rolling would occur at low angles of attack such as when the pilot pushed over to gain speed in the pre-flare manoeuvres before landing. It could, also, be brought on by gusts of wind or pilot inputs.

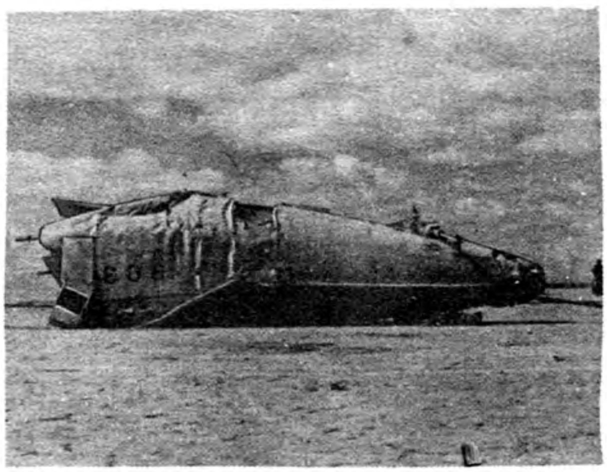
The standard recovery procedure was to increase the angle of attack. It could not be controlled by ailerons or rudder [14]. The second glide flight of 1967 (and the 16th of the M2-F2 programme) took place on 10 May. Bruce Peterson was the pilot.

The flight was for data on stability and control with emphasis on lateral directional characterists. After the drop, two 90° turns were made. Because of cross winds, Peterson made two S-turns to line up on the lake bed runway. After the second turn, the M2-F2 suddenly began to Dutch roll, building up to 200° a second and bank angles of 140°. Peterson had it back under control in 11 seconds. But the M2-F2 had gone off course. It was now a quarter to half a mile (nearly a kilometre) to the left of the runway. With no runway markings visible, Peterson could not judge his altitude. Also, the chase planes, which normally gave altitude callouts, had veered off. Distracting Peterson was a rescue helicopter nearby representing a collision threat.

Running out of time and altitude, Peterson had no choice but to initiate the landing flare without changing course. The flare was completed when the M2-F2 hit the lake bed. It bounced back into the air. The landing gear had partially extended when it hit again 80 ft (24 metres) from the initial impact point. The M2-F2 slid, then turned sideways and rolled over tearing off the main gear, canopy and right fin. It came to rest upside down, supported by the remaining fin and the seat support.

The rescue helicopter was the first on the scene. Peterson was pulled out and taken by helicopter to the Edwards Base Hospital for treatment of a skull fracture and severe facial injuries. A year and a half of plastic surgery was required for facial reconstruction [15].*

The programme, which had begun with such high hopes, was now at a halt. The M2-F2, nearly destroyed, the HL-10



The price: the M2-F2 after the crash of 10 May 1967. This was the only serious accident in the lifting body programme.

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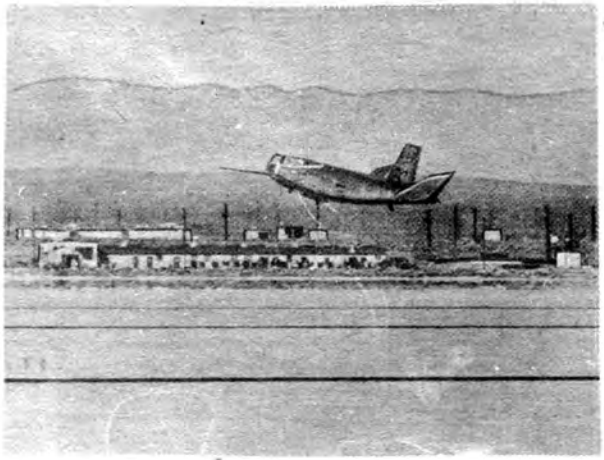


The HL-10 completes an early glide flight. Despite the early problems, it went on to be the highest and fastest of manned lifting bod bodies in its 37 flight programme.

NASA

un-flyable, and the Air Force X-24A programme facing funding and other difficulties. Martin Marietta had invested 'sizeable' amounts of company money in the programme and had built the two SV-5J jet trainers [17].

It would take nearly a year for the program to re-start. Two months after the crash, the X-24A was rolled out. During the summer and fall, there was a debate within NASA over the M2-F2. The Flight Research Center wanted to re-build it but NASA headquarters did not think it worthwhile. By November, however, serious consideration was being given to the idea; also undergoing consideration, was a change in the future plans that would give a wider role for the lifting bodies.

The Return of the HL-10

The gloom that had surrounded the lifting bodies was removed on 15 March, 1968 when Major Jerald R. Gentry flew the HL-10 in its second flight. The 4½ minutes flight checked out the design changes. March 22nd, the partial reconstruction of the M2-F2 was authorized so that it could be removed from the inspection jigs. It was to be returned to Northrop by late summer. May 28th, NASA pilot, John A Manke checked out in the HL-10.

The manned space flight programme was undergoing a significant change. The Apollo applications programme, announced in 1965, was to use the existing Apollo spacecraft and boosters. By early 1968, the NASA outlook had changed.

On 10 August, Dr. George E. Mueller, Associate Administrator for Manned Spaceflight, addressed a meeting of the British Interplanetary Society in London:

"I believe," he said, "that the exploration of space is limited in concept and extent by the very high cost of putting payloads into orbit and the inaccessibility of objects after they have been launched. Therefore, I would forecast that the next major thrust into space will be the development of an economical launch vehicle for shuttling between Earth and the installations such as the orbiting space station which will be operating in space".

**Despite the partial blinding of his right eye, Peterson resumed a test piloting career flying jet fighters and attack helicopters. In 1971, he became director of Flight Safety and Quality Assurance [16].*

His speech gave a new emphasis to the lifting body programme. No longer was it simply an exercise in basic research. Orbital transportation was now a goal for the post-Apollo period.

September 1969, the change became official. The space task group recommended a reuseable space shuttle system as part of an overall space exploration plan [18]. After 11 glide flights, the HL-10 was considered ready for powered flight.

On 23 October, 1968, Major Gentry attempted the first powered flight. After drop, the engine prematurely shut down. The HL-10 glided to a safe landing on Rosamond Dry Lake. The aircraft reached only 39,700 ft (12,104 metres) instead of the planned 45,000 ft (13,720 metres). November 13th, Manke made the first powered flight. After drop, he ignited two of the four engine chambers for 184 seconds and climbed from 35,000 to 42,650 ft (10,671 to 13,003 metres), investigating the effects of engine firing on stability and control. Top speed was 524 mph (845 kph). Manke said that the aircraft performed in "marvellous fashion" [19].

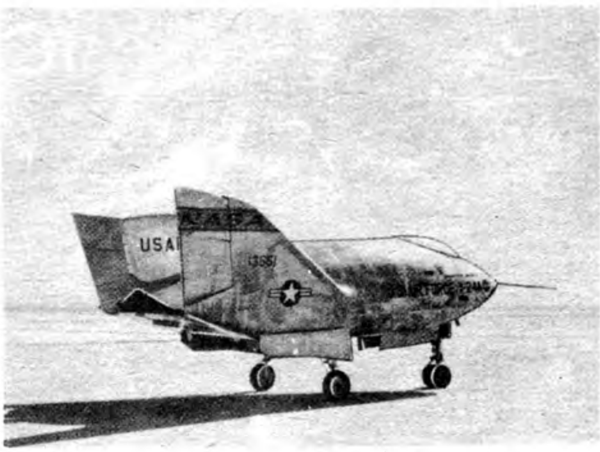
Enter the X-24A

April 17, 1969, the X-24A made its first glide flight with Major Gentry at the controls. The flight's purpose was data on longitudinal trim, lift/drag and pilot check-out.

In the meantime, a new pilot had joined the HL-10 programme. April 25th, William H. Dana, an X-15 astronaut, made his first glide flight. May 9th, on the HL-10's 17th flight, Manke reached a speed of 744 mph (1,198 kph) or Mach 1.13; the programme's first supersonic flight. The flight's purpose was stability and control data.

June 6th, Major Peter Hoag made his first check-out glide flight. Through the summer and fall, the HL-10 was tested at steadily higher speeds and altitudes in tests of its stability and control. August 6th, Manke pushed the HL-10 to 76,100 ft (23,201 metres) and a speed of 1,020 mph (1,643 kph) in the vehicle's first four-chamber flight [20].

Powered flight in the lifting bodies followed a pattern. After drop from the B-52 at an altitude of 45,000 ft (13,720 metres) and 450 mph (725 kph), the lifting body fired its engine, climbed and accelerated through the speed of sound. After engine shutdown, the lifting body would peak and begin to descend. It would follow the projected corridor that a lifting body would use returning from orbit. Descending along this steep path, the control movements would be made for flight data. Particular attention was paid to the



The X-24A poses on Rogers Dry Lake soon after its delivery. It was the third of the lifting body designs to fly.

NASA

transonic speed region. At 17,000 ft (5,183 metres), it would enter the landing pattern. At 10,000 ft (3,049 metres), it would begin the landing flare, extend gear and land on Rogers Dry Lake.

On 3 September, Dana reached M 1.45. November 17th, he topped this reaching a speed of M 1.59. The year ended with Dana reaching 79,960 ft (24,378 metres) December 12th.

While the HL-10 had been flying to ever higher altitudes and speeds, the X-24A had undergone a total of seven glide flights working toward a powered flight early in 1970.

The 70's and Beyond

In the new decade, the HL-10 continued its test programme. February 18th, Major Hoag made the fastest flight of a lifting body, reaching 1,228 mph (1,977 kph) or M 1.861. The purpose was to determine if there was roll reversal at high speed and to fly with the stability augmentation system off for extended periods.

February 27th, the highest flight by a manned lifting body was made. Dana reached 90,303 ft (27,531 metres); he opened the speed brakes while flying at supersonic speed. This flight completed, the way was cleared for powered descent and approach phase landing tests.

The HL-10 was temporarily grounded for removal of the XLR-11 engine. Three hydrogen peroxide rockets replaced it. They were used to determine the need for a space shuttle to have an on-board propulsion system for use during landing. The three engines could be fired separately to provide differing thrust levels.

February 24, 1970, the X-24A made its last glide test. During the 4 minute and 18 second long flight, Major Gentry tested the flap and rudder settings, the angle of attack and Mach number to be used during powered flight. The aircraft flew through turbulence with no difficulty. Modification to the gear doors eliminated a pitch-down tendency that had appeared earlier in the program.

March 19th, Major Gentry made the first X-24A powered flight, rocket operation, stability and control system and handling characteristics being the major goals. May 14th, during the third X-24A powered flight, two engine chambers failed to fire after drop.

During the reconstruction effort on the M2-F2, it had been given a centre fin. The lateral control system was modified, a jet reaction control system and improved internal components for precise manoeuvring were added. In light of the modifications, it was redesignated the M2-F3. Now three years after the crash, almost to the day, it returned to flight testing. A captive flight was made under the wing of the B-52, May 22nd, for systems check-out. June 2nd, Dana made the M2-F3's first glide flight since the crash. This time everything went well. The centre fin, aileron characteristics, control system and speed brakes were evaluated.

June 11th, The HL-10, with Major Hoag as pilot, made the first powered landing flight using the rockets. The nornormal 18° glide slope was reduced to 6°. On July 17th, the 37th and last HL-10 flight was made to evaluate and document the powered approach and straight-in GCA (ground controlled approach) as well as stability and control in subsonic configuration.

The HL-10 was put into storage at the Flight Research Centre. The X-24A flown by Manke and Gentry had, in the meantime, begun a series of flights to determine lift/drag and lateral directional derivatives at progressively higher speeds. These flights extended through the summer and fall.

August 26th, on what was to have been the first X-24A supersonic flight, two engine chambers failed to fire. After two unsuccessful ignition attempts, Gentry flew the alternate flight plan. A post-flight inspection revealed a fire had caused minor damage and an investigation was begun to find the source. It was not until 14 October that the X-24A was able to fly again. Manke reached M 1.19 and 67,900 ft (20,701 metres) in its first supersonic flight. Goals included expanding the envelope to M 1.1 and obtain lateral directional derivatives at supersonic speed, longitudinal trim and lift/drag ratio data with 40° upper flap.

On the next flight, October 27th, Manke reached 71,400 ft (21,768 metres), the highest altitude reached in the X-24A programme. November 25, 1970, Dana made the first powered flight in the M2-F3. Flight goals were: stability and control at M 0.8, check-out reaction controls and landing visibility. Special emphasis was placed on studies of lateral stability to overcome the problems that had nearly killed Peterson and wrecked the aircraft. The flight was marred by a premature engine shut-down and an investigation was launched [21].

February 9, 1971, Major Gentry flew the M2-F3 with the object of comparing the flight characteristics to those of the M2-F2. Major Gentry was the only M2-F2 pilot still active.

February 26, 1971, another M2-F3 flight was made to study lateral stability, envelope expansion to M 0.85 as well as stability and control at M 0.8 and vehicle stability. Dana flew this mission as well as all of the M2-F3 flights of 1971.

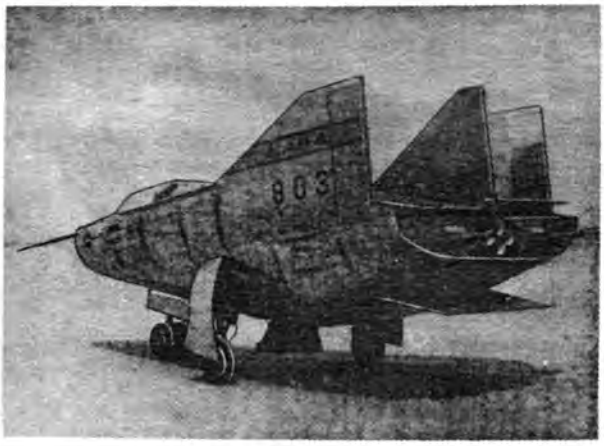
The X-24A also was active. February 5th, Major Cecil Powell made a glide flight. March 29th, Manke reached the X-24A's maximum speed of 1,036 mph (1,668 kph) or M 1.6. The flight was to explore lateral acceleration feedback, lateral directional derivatives with 2° rudder bias and expand flight envelope. Through the spring and summer, three more flights were made with similar goals by Powell and Manke. The 28th and last flight was on 4 June. July 29th, it was announced that the X-24A configuration was to be changed. The vehicle was to be stripped down and a long pointed nose and stub wings would be added. The X-24B's purpose was both to test space shuttle techniques and to gain information on low speed control of a vehicle capable of M 5-plus cruising speed. For actual Mach 5 flights, an advanced version, the X-24C was under study. The configuration also was more typical of the space shuttles under study at that time. The experience and data provided by the lifting bodies was of considerable importance in the design of a space shuttle.

The M2-F3 resumed tests on 23 July beginning a speed build-up. August 25th, Dana reached M 1.1, the M2-F3's first supersonic flight. The flight was to expand the flight envelope, determine aileron effectiveness at speeds greater than M 0.9, obtain stability and control data at M 0.95 and M 0.9 and evaluate speed brakes. The next flight, on 24 September, was cut short.

At drop, two rocket engine igniters malfunctioned shutting down the other two chambers. As the fuel was jettisoned, a small fire started in the tail area. It was extinguished when the fuel jettison was complete. The vehicle made a hard, but successful, landing on Rosamond Dry Lake.

In the wake of the accident, an extra glide flight was scheduled to check out the fuel jettison and engine chamber purge system. This was completed on 15 November. The way was clear to begin a series of flights to study stability and control above M 1 and evaluate the reaction control system [22]. Two flights were made December 1st and 16th. In January, 1972, the M2-F3 was grounded for installation of a command augmentation fly-by wire system. This was an entirely electronic method of controlling the aircraft in flight; such a system was to be used in the space shuttle.

Elsewhere that fall and winter, a controversy had been brewing. It now reached its conclusion. NASA and the Office of Management and Budget had been locked in a struggle over future plans. The point had been reached where the OMB was suggesting design changes and demanding to



Close-up of the M2-F3. Approximately one-and-a-half years of rebuilding was necessary after the crash. The most notable change is the addition of a centre fin. At its base is the four chamber XLR-11 engine.

NASA

know the dollar savings. Dr. James C. Fletcher, NASA Administrator, appealed to the Office of the President complaining that the OMB was trying to design the shuttle instead of funding it. President Richard M. Nixon removed the OMB accountant, Dr. Donald B. Rice, from the conference committee and demanded agreement. Dr. Fletcher flew to the San Clemente White House. There, on 5 January 1972, the President announced the approval of the space shuttle [23].

It was summer before the M2-F3 was ready to fly again. After three aborts, finally, on 25 July, the fly-by-wire system was checked out. August 11th, the M2-F3 began a series of flights for stability and control data at M 0.95. The maximum speed, also, increased–M 1.1 to 1.27 to 1.37 on the 100th heavy lifting body flight. Dana flew this mission on 5 October. Manke and Powell were checked out in the M2-F3 on 9 October and 9 November. The 100th lifting body flight marked the completion of the M 0.95 stability and control flight.

The studies were expanded to supersonic and low transonic speeds (M 0.7, M 0.8 and M 0.9). The first of these came on 1 November with Manke as pilot. They continued through 6 Devember; this last flight was made by Major Powell.

December 13th, Dana made the fastest M2-F3 flight to obtain stability and control at maximum speed. To achieve this, the drop was made at a higher altitude , 47,000 ft (14,329 metres) as opposed to the normal 45,000 ft (13,720 metres). The landing rockets were fired during the climb; the maximum speed reached was M 1.613. The reaction control system also, was checked out. On 20 December Manke made the highest and last M2-F3 flight reaching 71,500 ft (21,799 metres), to test the reaction control system during boost. This was the 43rd M2 flight, 16 of these as the M2-F2 [24].

The X-24B

Work on the X-24B, as the modified vehicle was now designated, was begun in January, 1972. The most striking feature of the new design, designated FDL-8, was the long pointed nose and stub wings. These served the dual purpose of increasing the cross-range capacity from 600 to 800 miles (966 to 1,288 km) to 1,200 to 1,500 miles (1,933 to 2,415 km) and improving the low speed behaviour. The extremely short blunt nose, of previous lifting bodies, would turn back the heat of re-entry but had a detrimental effect on low speed stability [25]. The work was performed at Martin Marietta's Denver, Colorado facility. By October, '72, the work was completed and the craft was returned to Edwards.

Programme pilots were John Manke and Major Michael V. Love.* During the summer, taxi tests and a captive flight were completed by Manke. August 1, 1973, after two postponements, the first X-24B glide flight was made. Before touch-down, Manke made a practice approach. A series of system check-out glide flights were made; the last on 4 October. This was a pilot check-out flight for Major Love. November 15th, after two postponements, the X-24B's first powered flight was made. Manke reached M 0.92 and 52,764 ft (16,087 metres) [26].

March 5th, 1974, the X-24B made its first supersonic flight with its new configuration reaching M 1.09 and 60,334 ft (18,395 metres). Stability and control at supersonic speeds, trim at M 0.8 and 0.9, as well as airflow around the fin were surveyed. On hand to greet Manke was Base Commander, Brig. General Robert Rushworth, an X-15 astronaut, and NASA Centre Deputy Director, David Scott, (Gemini 8 and Apollos 9 and 15) [28].

After three aborts, due to weather and B-52 problems, and a check captive flight, Love made his first powered flight on 30 April. A speed build-up was begun. Speed increased from M 1.14 May 24th to M 1.23 June 14th; M 1.39 was reached June 28th, M 1.54 on August 8, 1974. Finally, October 25th, Love reached M 1.76 or 1,164 mph (1,874 kph); this was the maximum speed reached in the X-24B, surpassing the record set by the X-24A, M 1.6 [29].

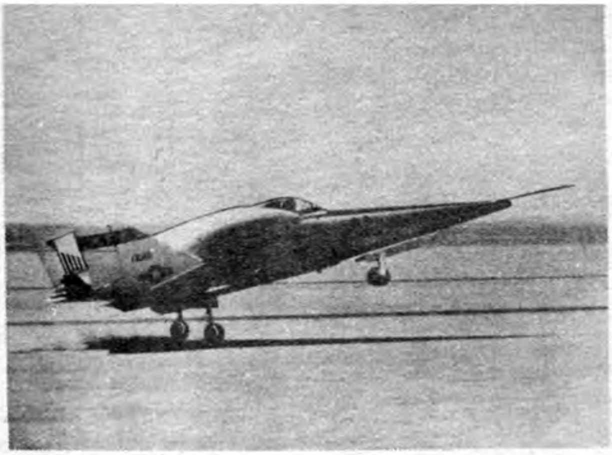
The X-24B programme can be broken down into three distinct phases. 1973 saw the initial tests. In 1974, the speed envelope was expanded. 1975, flight research was underway. By mid-year of 1975, such activities as stability and control at M 1.7, fin, rudder and flap pressure surveys, stability and control with various aileron bias, approach and landing with upper flaps at various settings were underway. It's most important research tasks were left until last. All the previous rocket-powered aircraft and lifting bodies landed on the lake bed; the X-24B was now to be the exception.

August 5th, 1975, Manke dropped from the B-52, his destination was the Edwards runway. The aircraft accelerated to M 1.23 and 60,000 ft (18,293 metres). Its glide angle coming back was 24°. Manke pulled up at 1,000 ft (305 metres) and made a perfect touchdown only 5 ft (1.52 metres) from the preselected point on the runway [30].

August 20th, Love made a second runway landing, proving that the shuttle could safely land on the runways at the Cape and Vandenberg. This flight marked the end of the X-24B's research programme but not its usefulness. It was to become a trainer to familiarise NASA and Air Force test pilots with the handling characteristics of lifting bodies [31].

Dana made two powered flights. The second, on 23 September, was the last rocket powered flight of a research aircraft. Three pilots were selected to make six more glide flights. The first on 9 October, 1975 was flown by NASA pilot, Einar Enevoldson. He had flown in such programmes as the 5/8 F-15 remote piloted vehicle programme and the supercritical wing F-111.

**Love was killed on 1 March, 1976, ironically in an RF-4C during a pilot proficiency flight. Cause of the crash was an emergency during take off, forcing an unsuccessful go-round attempt. It was believed by Edwards personnel that he hesitated to eject to prevent the aircraft from impacting in the base fuel pit. The death of the personable and well-liked test pilot deeply shocked the Base community [27].*



The X-24B touches down on the lake bed after a research flight late in the programme. The vehicle, last of the lifting bodies to fly, was built around the framework of the earlier X-24A.
NASA

The second glide was made 21 October by Major Frances R. Scobee. The experience was to be particularly valuable. A little over two years later, on 14 January, 1978, his selection as an astronaut was announced. The third pilot checked out was NASA test pilot, Thomas C. McMurtry, soon to be co-pilot of the 747 carrier aircraft. His first flight came on 3 November, 1975. November 12th and 19th, Enevoldson and Scobee each made a second flight. Finally, on 26 November, McMurtry touched down on the lake bed, bringing the last X-24B flight to an end.

Endings and Beginnings

So ended the last flight of the last rocket-powered experimental aircraft–the final chapter in an exciting period of human exploration. When it began, with the first glide flight of the X-1 in 1946, space seemed far away, made remote by the unknowns it presented and the questions that could not even be asked. In the next three decades, each successive flight, of first air and then spacecraft, had pushed back the limits of the frontiers: the mysteries explored, the answers found. The time of experimentation had ended. Across the desert, Space Shuttle 101 was taking shape . . . .

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Bell Aerospace Textron: Donald J. Norton.

Disposal

The mock-up of the Dyna-Soar was scrapped at the cancellation of the programme. The M2-F1 and the HL-10 are in storage at the Dryden Flight Research Centre and are, occasionally, on public display for air shows. The M2-F3 is on display at the Smithsonian Institution's National Air and Space Museum. On display at the Air Force Museum at Dayton, Ohio, is the surviving third ASSET, the third X-23 and the X-24B. Beside it is one of the SV-5J's painted to represent the X-24A. The SV-5J's were never flown under their own power.

175 DAYS IN SPACE

Looking none the worse for their record space flight of 175 days aboard the Salyut-Soyuz orbital complex, cosmonauts Vladimir Lyakhov and Valery Ryumin spoke of their experiences at a Moscow press conference.

"The successful landing of Soyuz 34 and the return of our crew to Earth marks the completion of an important stage in the Soviet space research programme," Vladimir Lyakhov, the space complex commander,said. "The experience of previous long-duration missions aboard the same orbital station, Salyut 6, was of great importance for the fulfilment of our task.

"We continued the already established 24 hour cycle of work and rest periods in accordance with Moscow time. An average of 35 per cent of the time was occupied by professional activities, the remainder by sleeping, eating, resting and personal hygiene."

He expressed the hope that the results of the work in orbit would be widely used in many fields of science and the economy and would serve as a basis for future long-term expeditions.

Flight-Engineer Valery Ryumin pointed out that the use of Progress cargo ferries had made it possible to modernise the station as a scientific laboratory by supplying it with new scientific and technological equipment during the flight. "A considerable part of the programme in orbit," he said, "consisted of testing new equipment and methods of perfecting space navigation."

The importance of cargo ships was also referred to by Vladimir Lyakhov, who spoke of the expanding possibilities for research they opened up. In particular, he mentioned the delivery to Salyut 6 of results of analyses made on Earth of data obtained during the early months of flight, which had made it possible to correct research methods in the course of a single expedition.

Both cosmonauts commented that the most important thing about their flight had been the amount and variety of the research carried out, rather than its record duration.

A LONG-TERM POLICY FOR EUROPE

For more than a year, EUROSPACE has been engaged in an investigation which has brought together the thinking of European industry on a matter of concern to all of us–the political, social and economic needs which will affect Britain and Continental Europe up to the year 2000, and how space applications can fulfil many of those needs. The investigation, which forms part of recommendations to the European Space Agency, has been consolidated into a report entitled "Proposals for a European Long Term Space Policy", which is summarised below.

Introduction

In the first instance, questionnaires were circulated widely throughout industry and discussed at length within the EUROSPACE Industrial Policy Committee. The opinions that were collected and analysed proved remarkably coherent, and enabled us to establish a list of needs relating not only to economics but to social, moral and political questions as well. Eventually, the list was reduced to 16 items, the first 8 of which call for specific European actions, with the remainder being common to Europe and the rest of the world.

The first eight are:

1. Unification of Europe
2. The expansion of European exports
3. Today's economic stagnation
4. Lack of energy resources in Europe
5. Lack of raw materials in Europe
6. Social unrest
7. Lack of morale in Europe
8. Defence

The second group of eight needs are:

9. Protection against catastrophe, accident and terrorism
10. Traffic problems–land, sea and air
11. Management of world resources
12. Pollution
13. Poverty and lack of education in the Third World
14. Population problems–including urbanisation, over-population, under-population, and unbalanced population distribution
15. Better medical care
16. The quest for knowledge

Contribution of Space Techniques to the Fulfilment of European Needs

It is clear that space techniques can bring a contribution to the solving or alleviation of most of these needs, and in many instances they can do so in the very near future. For example, the use of telecommunications satellites and remote sensing satellites can help very efficiently in the fight against poverty and educational problems in the Third World, while the use of space laboratories can bring about the preparation of better pharmaceutical products to assist in medical care.

As far as Europe is concerned, the development of direct television satellites can bring an increasing awareness of belonging to one community, while survey satellites can clearly help in pollution control, direction of fishing fleets, and so on.

Many such space programmes, well-suited to the solution of many of the needs, were thus identified, but the difficulty was to recommend priorities in the light of the technical and financial constraints that would apply in Europe.

Priority Space Programmes for Europe

A lot of time was spent on this matter of priorities, and the EUROSPACE working group presented a list of space programmes which, in its view, seemed to offer the greatest promise up to the end of this century. The programmes were classified into seven categories:

- Communications
- Meteorology
- Earth Survey
- Space industrialisation and energy
- Scientific research
- Military programmes
- Space transportation systems and space laboratories

The first three categories–communications, meteorology and Earth survey–have an important point in common. Previous development has proved the validity of these space techniques, and now the time has come for the operational use of European satellites for these categories; the necessity for such operational programmes cannot be overstressed. However, it is clear that the next generations of such spacecraft have to be prepared, and these generations will be characterised by the use of large, multi-purpose telecommunications platforms and antenna farms, and more advanced types of sensors, data handling systems and platforms for meteorology and remote sensing.

Thus, within these three categories, six programmes are recommended:

For COMMUNICATIONS, operational use of the satellite types already developed for telecommunications, direct television, maritime services, and so on, with a target date of now. Followed by the development of the next generation of communications satellites, including the large platform of several tons in geostationary orbit, with a target date at the end of the eighties.

For METEOROLOGY, the operational use of satellites already developed, such as Meteosat, as soon as possible, followed by the development of new satellites aimed at 1985.

For EARTH SURVEY, the preparation of Spot-type satellites for the mid-eighties, followed by development of next-generation spacecraft, with larger, heavier platforms, with an end-eighties target date.

In the next category, SPACE INDUSTRIALISATION, three programmes were considered to be of prime importance.

First is the utilisation of Spacelab, which will begin in the early eighties. Experiments on-board Spacelab will play a large part in identifying those processes in the fields of materials and pharmaceutical products that will eventually

lead to industrial applications in space. The results of this programme will undoubtedly lead to Europe finding it necessary to embark on a second generation of space laboratories, which could be free-flyers—manned or automatic—and more will be known about this by the mid eighties.

Second is the production of electrical energy by geostationary solar stations—a widely publicised programme, which will eventually be in partial operation by the end of the century. An expensive programme, too, but of such impact on our energy needs that Europe cannot afford not to prepare for action on its own in this field.

The third programme is aimed at the end of the century, or even after. It is the use of fail-proof launchers, or fail-proof combinations of launchers and containers, to dispose of nuclear waste by launching into the Sun or into deep space. This is a controversial subject, but one that cannot be ignored without in-depth study as soon as possible.

The next category, SCIENTIFIC RESEARCH, is clearly a necessity for a continent that wishes to maintain a high standard of scientific and technological knowledge. Here the study group felt that insufficient attention was being paid to two aspects of scientific missions, namely, enabling industry to develop its technologies and making an impact on the public by choosing spectacular missions rather than dull ones—dull to the public, that is.

Concerning the category of MILITARY PROGRAMMES, it is clear that communications and observations satellites will be of use to Europe, and it is hoped that the competent authorities will call for such systems in good time.

In the last category, SPACE TRANSPORTATION SYSTEMS AND SPACE LABORATORIES, three subcategories were proposed.

Firstly, there is the commercialisation of ARIANE, then the continuation of its development, so that Europe can launch not only its own telecommunications and earth observation platforms, but also space laboratories. Then there is the preparation of European space laboratories—automatic or visitable—eventually with a system of relay satellites to control them in real time. Lastly there is—probably—the development of a capability in placing Europeans in orbit to work in space independently of other powers.

Secondly, there is continuation of cooperation with the USA, already lively in the Spacelab programme, with particular emphasis on:

- Improvements to the present Spacelab;
- Cooperation in the preparation of free-flyer modules, space stations and orbital operations;
- Preparation of orbit transfer vehicles;
- Development of ion propulsion engines;
- and, eventually, participation in the second generation of Shuttle.

The third sub-category concerns preparation for a new type of vehicle. It is the opinion of many that space industrialisation and energy programmes cannot become realities unless a new, low-cost launcher optimised for very heavy payloads, is developed. Such a development could probably not take place before the late nineties, but it will be important for Europe to play a siginificant role in it.

It might have been noticed that this list of categorised programmes does not contain items that are often mentioned in the specialised press, such as laser energy transmission; lunettas for the lighting of cities; zero-gravity hospitals; and electric mass drivers. It is not that such concepts are not of interest—it is simply that it was felt that, unfortunately, Europe could not afford action in these fields to any significant scale.

In COMMUNICATIONS, the development programme recommended is that for a large, very heavy, multipurpose geo-stationary platform, weighing more than two tons in orbit, for launch in 1987-'88. This platform would allow experimental applications in aircraft communications, exchanges between satellites, direct radio broadcast and high frequency transmission trials.

The total cost would be 230 Million Accounting Units, or MAU for short. Today, one AU is the equivalent of around 1.2 US dollars.

In the METEOROLOGICAL FIELD, it is being assumed that the European meteorological administrations will jointly finance the operational programmes directly derived from Meteosat; it is proposed that ESA should develop two satellites, one a geostationary spacecraft with higher performance than Meteosat, with a launch date of around 1986, and a low orbit satellite for climatology, with a 1984 launch. The total cost would be around 310 MAU.

For EARTH SURVEY, the Agency has already proposed the development of two new satellites, one for land applications and the other for coastal zone monitoring. The EUROSPACE proposal is that these satellites should be developed and launched around 1985-'86 but that, in addition, Europe should develop a larger Earth survey platform with new instrumentation, for launch in 1990. Total cost is seen as 660 MAU.

In SPACE INDUSTRIALISATION, it is recommended that ESA should devote a reasonable budget to technical and economic feasibility studies, and that the Agency should also prepare an experimental platform, aiming at experimenting, on a relatively large scale, in construction in space, generation of electrical power, and transmission of power by microwave, with a total budget of 550 MAU.

In the field of SCIENCES, EUROSPACE proposes action in the fields of materials and life sciences, and a number of satellites for astronomy, atmospheric and planetary research. These would involve three especially attractive programmes:

- A mission to the Encke comet;
- The establishment in space of a large radio-astronomy antenna, which would provide further opportunity to work on large structures in space;
- And a mission to the planet Mars. This is envisaged as a cooperative mission with the USA, the United States providing the launcher and Europe providing a Mars rover; that is, a vehicle that could be landed on Mars and accomplish various tasks there. This would, indeed, be a spectacular and exciting programme.

The total budget estimated is 1140 MAU.

Two main lines are recommended in the fields of SPACE TRANSPORTATION and SPACE LABORATORIES. Firstly, new developments of ARIANE are proposed, leading to the building of a fully recoverable hydrogen-oxygen stage, and a reinforced first stage, permitting the launch of large, heavy payloads, weighing more than two tons in geostationary orbit, and ten tons or so in low orbit. Secondly, concerning cooperation with the USA, it is recommended that ESA proposals be adopted for Spacelab follow-on, including preparation for free flyers and, eventually, elements of space stations, together with cooperation in orbital operations and work on orbit transfer vehicles and ion propulsion. The total budget envisaged amounts to 1090 MAU.

Regarding European space laboratories, automatic or visitable, heavy lift vehicles, and manned space transport

[Continued on page 518

THE REMOTE MANIPULATOR SYSTEM

By Gerald L. Borrowman

Introduction

THE CORNERSTONE of all United States' space activities for the next decade – the Space Shuttle – will pave the way for space to be utilised in ways previously contemplated only in science fiction. Canada is contributing "a mission critical" element to the Space Shuttle. It is the Remote Manipulator System (RMS) which is an analogue of the human arm. The RMS will be able to perform such duties as transferring astronauts from a disabled Orbiter to a rescue vehicle, repair, recalibration and even retrieval of malfunctioning satellites.

A Lockheed study in 1974 of 131 satellite failures revealed that 78 were related to launch problems and 53 to spacecraft anomalies; had this system been available many of these failures could have been avoided. The Orbiter's cargo-carrying capacity means satellite designers need no longer operate under severe weight constraints imposed by expendable launch vehicles, so comparatively inexpensive materials and standard laboratory equipment can replace expensive materials and highly miniaturised components.

The Space Shuttle will permit cost reductions and increased carrying capacity and the orbiting of more powerful and complex satellites. Telesat Canada, the corporation that operates the Canadian satellite communications systems, has already prepared a generation of high-frequency satellites, Anik C-1 and Anik C-2, both scheduled for launch in 1980. These satellites will occupy but a quarter of the voluminous Shuttle payload bay and Telesat Canada expects to save one-half of the launch cost of conventional rockets. The $21 million price tag of a Delta 3914 is slashed to $10 million with the Shuttle (1975 dollars).

The dialogue between the Government of Canada and NASA began in 1969 as an offer for Canadian participation in the Post-Apollo programme. The offer was made on the occasion of a presentation to senior officials of the Canadian Government by senior NASA officials. At that time NASA was still considering if the Post-Apollo era should be directed toward establishing a space station in Earth orbit or developing the Space Shuttle. By the end of 1969, the Space Shuttle received first priority. The result was that Canada agreed to undertake the design, development, flight qualification and manufacture of the first flight unit of the R.M.S. A memorandum of understanding was concluded in July 1974 as part of a policy to expand space activities by the Government of Canada.

Remote Manipulator System

The commencement of the Remote Manipulator System Program gave jobs to engineering teams that would otherwise have been disbanded. Canada was afforded the opportunity to develop a potentially lucrative technology. This undertaking gives Canada preferred access to the Shuttle for satellite launches and for Spacelab experiments. This is important for Canada as the country's immense geographical size imposes a dependence on sophisticated technology, particularly satellites.

A consortium of Canadian companies led by Spar Aerospace Products Ltd., was contracted to construct the RMS under the auspices of the National Research Council of Canada. The design and fabrication of the RMS was a carefully orchestrated process. Once the mass of the arm is set in motion in the weightless environment of space, it would keep going until an equal opposing force is applied to bring it to a halt. Although designed to move as much as 29,545 kg. in the weightlessness of orbit it will be unable to move its own weight under Earth's gravity.

Engineering Model Manipulator Arm (minus wrist and end effector) undergoing test on air bearing floor at SPAR Aerospace Limited, Toronto, Canada.

Much of the testing and simulation of the RMS employs a computer to process the exceedingly complex mathematical models which describe the manipulator's motions. As much as 60 per cent of all proving will be conducted by computer. The remainder is performed by swinging the arm in only two dimensions on an extremely flat floor to rule out the effects of gravity.

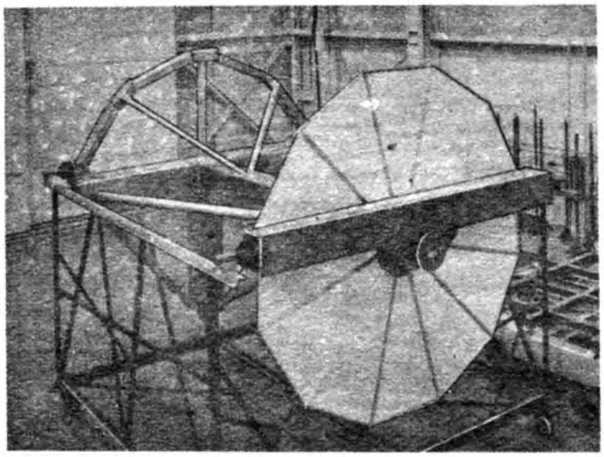
At the Communications Research Center in Shirley Bay, Ontario, a facility of Canada's Department of Communications, the RMS components will be subjected to a series of punishing tests to evaluate their performance in conditions simulating the hostile environment in outer space.

The manipulator is 15.2 metres long and able to manoeuvre cargoes up to 18.3 metres long, 4.6 metres in diameter. A payload of 25,000 kg. can be deployed to a position 9 metres above the Orbiter in less than nine minutes. The arm is attached to the spacecraft by a shoulder joint and is hinged at its mid-point with an elbow joint. The arm's six rotating joints, each with six small motors, can assume any desired orientation. The robot's hand is a series of "grippers" that snare a grappling fixture on the payload.

The extreme heat and cold of space necessitates elaborate measures to protect the arm. Radiant heat is reflected by a multi-layered blanket of plastic and aluminium film. The cold is combated by a series of thermostat controlled heaters.

The Work Station

From a work station on the Orbiter's flight deck the operator can monitor the motions of the manipulator through a set of overhead windows and a second set overlooking the cargo bay. A series of lights and television cameras within the cargo bay and on the manipulator arm provide a view on two television monitors. In the operator's left hand is a stick that moves the manipulator back or forward, up or down, to one side or another. In the right hand is the control for up or down, and orientation of the arm. Side to side motion of this stick determines the speed at which the arm moves. When the operator presses a



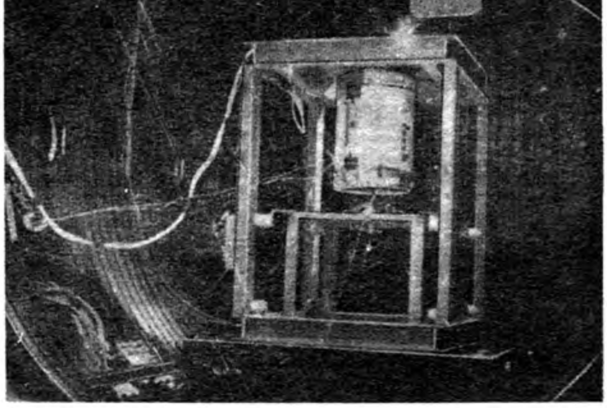
Full scale mock-up of Payload Handling Flight Test Article to be flown during Orbital Flight Test (OFT).

button beneath the thumb of his right hand around a grapple mounting on the payload. The dexterity of the system is such that a manipulator attached to one Shuttle can remove payloads from a second Shuttle if the two vehicles fly within approximately 35 ft. of each other.

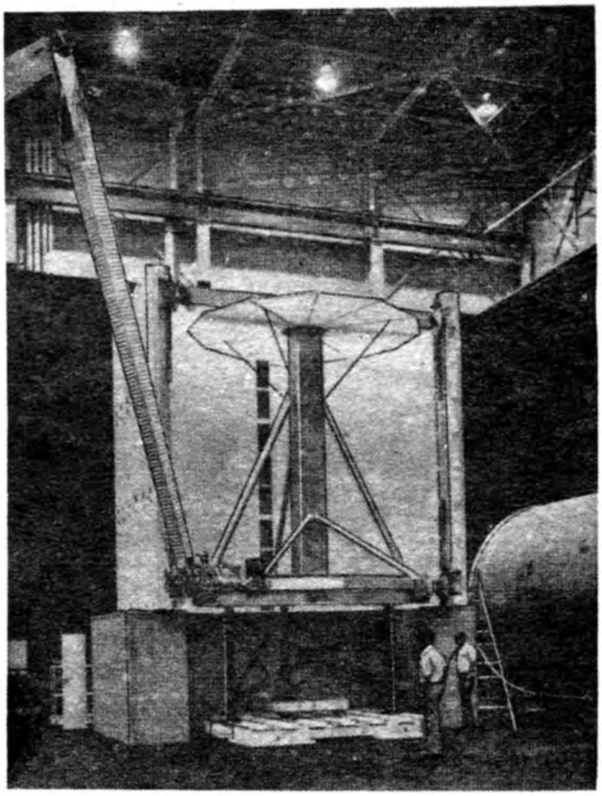
A major programme milestone was reached in April 1978, when representatives of the National Research Council of Canada, NASA, and the US Air Force scrutinised tens of thousands of pages of documents, drawings, and working models. Collective approval was given to the programme and it was allowed to enter the final phase of hardware construction.

Despite no such tool having been built before, the programme is on schedule. The completed product was due to be delivered to NASA in July 1979, for flight on the third test flight of the Shuttle. At a time when Canada's unity is being tested, cooperation in international space efforts serves to satisfy the aspirations of its citizens.

The abilities of the Space Transportation System will permit modularisation to become an important future configuration for work-a-day satellites designed for quick check-out and easy replacement of failed equipment. HEAO-2 launched in late 1978 carried the first "retrieval fixture" which would allow it to be conveniently grasped by the manipulator arm.



Payload Handling Flight Test Article berthing test in the Manipulator Development Facility (MDF), Johnson Space Center, Houston, Texas.



Engineering Model End Effector in thermal vacuum test at David Florida Labs, Ottawa, Canada.

All photos National Aeronautics and Space Administration.

The Teleoperator Retrieval System (TRS), which was due to be used to re-boost the Skylab orbiting space laboratory to a higher orbit or to de-orbit it to a remote ocean area, is now being subjected to a process of re-evaluation. The actual configuration/performance capabilities of TRS will be the subject of further studies over the next two years One of the growth kits that could be added to the TRS with minimum integration cost is a set of manipulator arms. This would further complement Shuttle Orbiter capabilities in the realm of payload inspection and retrieval operations.

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NEXT MONTH

We take this opportunity of wishing all our readers a Happy and Prosperous New Year. Articles appearing in the January issue will include "Navstar – A Complete Global Navigation System," by Geoffrey Richards; "Return to Apollo," by Andrew Wilson and David Shayler, and a digest of discoveries about the planet Venus. We shall also be featuring illustrated reviews on the NASA Space Shuttle and the ESA Ariane.

SPACE REPORT

A regular monthly review of Space Events and Technical Trends

WINTER ON MARS

More than three years after NASA's Viking spacecraft landed on Mars scientists at the Jet Propulsion Laboratory are still receiving data from one orbiter and two landers.

The Viking mission has gone into a fourth major stage, called the Survey Mission, and the first data from that period has been received at JPL. The Survey Mission is scheduled to continue through 1990, more than 15 years after the spacecraft were launched.

Both Viking landers and the remaining orbiter are operating. The landers have been placed in an automatic condition that allows them to function unattended; Lander 1 transmits its information to Earth once a week.

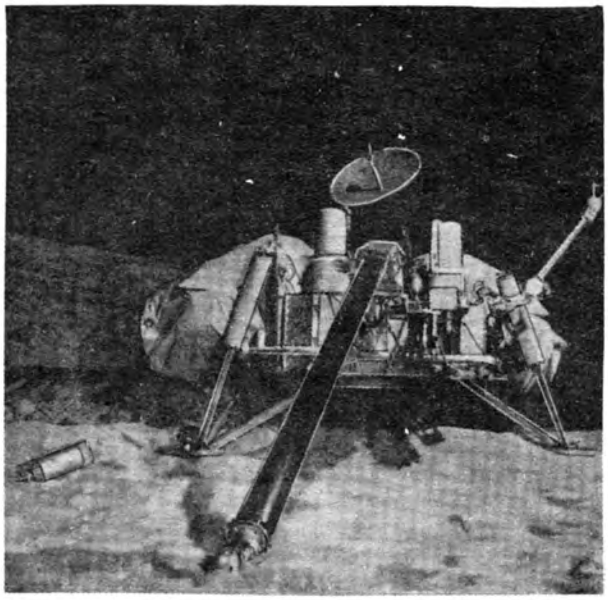
Viking Orbiter 1 is taking high-resolution pictures of the Martian surface with a clarity not obtained before, since the Martian atmosphere has become unusually clear. (Viking Orbiter 2 was shut down on 24 July 1978, after it ran out of attitude-control gas; Viking Orbiter 1 is expected to cease operations sometime in 1980). Landers 1 and 2 continue to take pictures and to collect weather data.

Lander 2's cameras have revealed a new layer of water frost on the Martian surface at the Utopia Planitia landing site. It is Martian winter again, and a thin layer of frost can easily been seen in the photos.

The new frost layer poses a scientific puzzle to members of the Viking team: In September 1977, Viking Lander 2 found frost on the surface during the Martian northern winter. Scientists associated that frost collection with a major dust storm that had obscured the planet's surface before and during that period.

But recent observations have shown no dust storms on Mars this year – in fact, the atmosphere is clearer than scientists have seen it since Viking arrived in 1976. So no one is certain just what triggers the appearance of frost.

This much is believed: Dust particles in the atmosphere pick up bits of solid water (ice). That combination is not heavy enough to settle to the ground. But carbon dioxide, which makes up 95 per cent of the Martian atmosphere, freezes and adheres to the particles and they become heavy enough to sink. Warmed by the Sun, the surface evaporates the carbon dioxide and returns it to the atmosphere, leaving behind the water and dust. The resulting frost layer may be only one-thousandth of an inch thick.



VIKING SIMULATOR. The Viking Science Test Lander (STL) installed in the Atrium of JPL's Von Karman Auditorium. The STL has been used for boom and camera tests and could be programmed to duplicate the surface sampler movements of the Landers on Mars as an aid to remote controllers on Earth.

National Aeronautics and Space Administration

ICE ON MARS. This high-resolution photograph of the surface of Mars was taken by Viking Lander 2 at its *Utopia Planitia* landing site on 18 May 1979 and relayed to Earth by Orbiter 1 on 7 June. It shows a thin coating of water ice on the rocks and soil. The time the frost appeared corresponds almost exactly with the buildup of frost one Martian year (23 Earth months) before.

Jet Propulsion Laboratory, NASA

MIGHTY JUPITER. This magnificent colour composite made from Voyager 2 narrow-angle camera frame shows the Great Red Spot during the late Jovian afternoon. North of the Red Spot lies a curious darker section of the South Equatorial Belt (SEB), the belt in which the Red Spot is located. A bright eruption of material passing from the SEB northward into the diffuse equatorial clouds has been observed on all occasions when this feature passes north of the Red Spot. The remnants of one such eruption are apparent in this photograph. To the lower left of the Red Spot lies one of the three long-lived White Ovals. The photograph was taken on 29 June 1979 when Voyager 2 was more than 9 million km from the giant planet. The smallest features visible are over 170 km across.

NASA

GREAT RED SPOT. This mosaic of the Red Spot shows that the region had changed significantly since the Voyager 1 encounter three months before. Around the northern boundary a white cloud is seen, which extends to east of the region. The presence of this cloud prevents small cloud vortices from circling the spot in the manner seen in the Voyager 1 encounter. Another white oval cloud (different from the one present in this position at that time) is seen south of the Red Spot. The internal structure of these spots is identical. Since they both rotate in an anticyclonic manner these observations indicate that they are meteorologically similar. This image was taken on 6 July from a distance of 2,633,003 km.

NASA

DARK CLOUD. This image returned by Voyager 2 shows one of the long dark clouds observed in the North Equatorial Belt. A high, white cloud is seen moving over the darker cloud, providing an indication of the structure of the cloud layer. At right, blue areas, free of high clouds, are seen. Photo was taken on 6 July from a distance of 3.2 million km.

NASA

'OASES' ON MARS?

A report by four University of Massachusetts astronomers that they had found evidence of two large subsurface accumulations of water on Mars was presented at the 10th annual Planetary Geology Principal Investigators' Meeting at Brown University, writes Gerald L. Borrowman. The "oases," one said to be 400 miles (643 km) in diameter and the other 720 miles (1,158 km), could play a role in the planet's periodic dust storms. Data from an Earth-based telescope and water-detection devices aboard the two orbiting Viking spacecraft have shown water evaporating from two sites on Mars, said Robert L. Huguenin, associate professor of physics and astronomy.

One site, *Solis Lacus*, "appears to be more hospitable than some of the extreme environments on Earth in which microorganisms have been found to adapt and thrive," the researchers reported. "It would appear that *Solis Lacus* may be an oasis on an otherwise dry planet."

Evidence from remote sensing devices shows water in *Solis Lacus* "that extends to a few centimetres of the surface," the researchers said. Pictures taken from orbit "revealed formations that were probably carved by large amounts of water." Others show frost and fog coming from the region.

Temperatures at the two sites range from 70 degrees Fahrenheit during the day to 107 below zero at night, the researchers said. For about seven hours a day, it is warm enough for ice in the soil to melt.

However, in response to these presentations, a spokesman for the Jet Propulsion Laboratory stated: "Our people are in 100% disagreement with the Huguenin assumptions." He went on to explain that "there are no photographs of *Solis Lacus* or any other... area to bear out this (Huguenin's) theory."

AMERICA'S TWENTY-YEAR ASTRONAUT

By David J Shayler

The Anniversary

On 9 April, 1979 Major Donald Kent Slayton, USAF (Retired) celebrated an historic anniversary by becoming the World's longest serving spaceman, twenty years. He was one of the first seven Americans selected for Astronaut training and remains the only one of these elite seven still with NASA, a remarkable record. The climax of his career was reached in July 1975 when at the age of 51 Slayton began his first spaceflight after waiting some 16 years mostly because a medical problem forced his grounding from active participation in American space flights.

The Early Years

Donald K Slayton was born on 1 March 1924 in Sparta, Wisconsin. Here he was raised with three brothers and two sisters in a typical American small town environment. Following graduation from Sparta High School Slayton enlisted as an aviation cadet and received his wings in April 1943 after completing flight training at Vernon and Waco, Texas. He then was posted to Europe for combat duty as a B-25 pilot with the 340 Bombardment Group flying a total of 56 combat missions during his tour of duty. He was awarded the Air Medal with Cluster for his service in the European theatre. In mid-1944 he returned to the US and served as instructor pilot for B-25's at Columbia, South Carolina. He later served with a unit responsible for checking pilot proficiency in the B-26 also at Columbia. In April 1945 he was posted to Okinowa with the 319th Bombardment Group flying seven combat missions over Japan before the end of the war. He is the only American astronaut to gain combat experience in both Europe and the Pacific during the Second World War.

Post War Assignments

For 12 months immediately following the end of the War Slayton served as a B-25 instructor before leaving the Air Force to enter the University of Minesota, Minneapolis, receiving a Batchelor of Science Degree in Aeronautical Engineering from the University in 1949. For two years following graduation he worked as an Aeronautical Engineer for the Boeing Aircraft Corporation, Seattle, Washington, before being recalled to active duty during the Korean conflict in 1951 with the Minesota National Air Guard. This time however Slayton had decided to make a career out of the Air Force.

Upon reporting for duty he was assigned as Maintenance Flight Test Officer of an F-51 Squadron located in Minneapolis, followed by 18 months as a technical inspector at Headquarters, 12th Air Force. In 1953 a similar tour as flight pilot and maintenance officer with the 36th Fighter Day Wing at Bitburg, Germany, followed.

Marriage and a family

It was while he was in Germany that Slayton met a lively dark-haired girl from California, Marjorie Lunney, who at this time was working as a secretary for the USAF in Berlin. She was born in Los Angeles where her parents, Mr and Mrs George Lunney, still lived. In early 1955 they were married and honeymooned in Paris before returning to the United States in June 1955, so that Deke could commence his new assignment at the USAF Test Pilot School at Edwards Air Force Base, California. He was a test pilot there from January 1956 to April 1959. On 8 April, 1957, another important event occurred in the life of Deke Slayton; his wife gave birth to their only child, Kent.

Donald Kent 'Deke' Slayton.
NASA

One of Seven

Late in 1958 he decided to apply for the space programme as astronaut candidate for the forthcoming Mercury programme. Following extensive interviews, tests and examinations he was notified of his successful selection on 1 April 1959, and told to report to Langley Field, Virginia, to be assigned duties within NASA and commence training for manned space flight. [1] The immortal "Original Seven" Mercury astronauts were publically viewed for the first time on 9 April, 1959; America had her first real Astronauts and Deke Slayton had new goals to accomplish in his flying career.

He set very high standards for himself during the initial training programme for Mercury. He established a record of endurance on the treadmill and pulled 9.2 g's before blacking out in centrifuge tests. He frequently flew high performance jets without a 'g' suit. Like all of his fellow Mercury astronauts, he desperately wanted to be the first man in orbit.

When asked shortly after his entry into the space programme what new efforts are needed for spaceflight, he said:

"I don't feel that any particular extra faith is called for in this programme over what we normally have. This is just an extension of flight. We've gone about as far as we can on this globe, so we'll have to start looking around a bit. I feel I'm in on the ground floor of something human beings will be concentrating on for the next thousand years–if we don't destroy ourselves in the meantime" [2].

Mercury Assignments

Slayton's speciality in technical fields of the Mercury programme was the Atlas launch vehicle [3]. At that time (early 1960) the Atlas programme was suffering several minor setbacks but nevertheless Slayton stated: "There's no question about the ability of the Atlas to put us into orbit; our only problem here is reliability which so far isn't good. But we know it will have the bugs worked out of it by the time we're ready to use it" [4].

In 1961 he was awarded an Honorary Doctorate in Science from Carthage College, Illinois.

He was selected to fly America's second manned orbital flight MA7 but did not succeed. In August 1959 NASA doctors had discovered a slight heart flutter in Slayton. All the same, his training programme continued with medical

opinion divided on his fitness for the upcoming flight even though he performed his preflight rigorous training tasks extremely well.

During the first American orbital mission in February 1962 Slayton provided "valuable technical data" [5] for John Glenn and was simultaneously gaining control procedures first hand for his assigned flight, then only three months away.

The final decision on whether Slayton should pilot the second orbital flight was left to a higher authority. NASA Administrator, James Webb, carefully weighed up all the evidence available to him and finally reached his decision; Slayton would not be making the flight. His place would be taken by Glenn's backup, Scott Carpenter [6].

It was 15 March 1962, just over two months before the scheduled launch, and came as a bitter blow. Slayton lost the chance of becoming the second American in orbit. He also probably lost the chance of making a second flight in Gemini and the possibility of flying as Commander of an Apollo lunar mission. Nevertheless, he assisted Carpenter with preparations for his upcoming flight.

Slayton busied himself with ground duties in the Mercury programme and acted on several occasions as Capsule Communicator (CapCom). He was the only one of the "Original Seven" not to fly in a Mercury type spacecraft.

Role of Importance

Slayton became Coordinator of Astronaut Activities in September 1962 and was responsible for the newly formed Astronaut Office. In November 1965 he resigned his commission as an Air Force Major to assume the role of Director of Flight Crew Operations. In this capacity he was responsible for directing the activities of the Astronaut Office, the Flight Crew Integration Division [8]. Also in 1963 he participated in the selection board of the Group 3 astronaut group. With Al Shepard as Chief of the Astronaut Office, Slayton was responsible for the selection of the astronauts who flew all American space missions from Gemini 3 to the Shuttle Orbital Flight Tests this year (Shepard left NASA in 1974, his place being taken by John Young who is currently in training for the first Shuttle orbital flight. He in turn has been replaced as Chief of the Astronaut Office by Alan Bean).

It was Slayton who worked out the system of how a backup crew to one flight then skips the next two flights to fly as prime crew on the third. This system was the base line for America's manned space flights from Gemini 3 in March 1965 to Apollo 17 in December 1972. Without doubt the position which Slayton held was one with enormous power in deciding the fates of the other astronauts and undoubtably he was the man primarily responsible for selecting the 12 men who walked on the Moon.

When Slayton and Shepard had worked out the crew assignments they submitted their proposals to the Johnson Space Center Director who in turn passed them on to the Associate Administrator in Washington for final endorsement [10].

"There isn't any big magic selection that goes on for each mission," Slayton once said. "Everybody wants to be on a crew; that's normal. I can appreciate that more than any one. I'm not in a job where you can worry much about whether people love you or not. You've got a job to do and you hope it's right. This is like handling a squadron of fighter pilots. You've got a mission to do and you've got so many flights to fly and you assign guys to fly them. Sometimes you ask the Commander about the composition of his crew, but then again it goes far back. We know who gets along and who doesn't. If you've got some options you give the Commander a choice of three or four guys. Sometimes you don't have any choice. We've never pulled a man because of any personality conflict. If that happened, it would mean you had made the wrong selection in the first place" [11].

In 1965 he received an Honorary Doctorate in Engineering from Michigan Technological University, Houton, Michigan. Also in 1965 he participated in the selection of NASA's first Scientist-Astronauts.

During his years with NASA Slayton had attended nearly all the breakfasts with the prime crews on the day of launch; the event has become part of a tradition.

In 1966 Slayton's time was taken up with another astronaut selection board, the ending of Gemini flights and the preparations for the first manned Apollo flights scheduled for 1967. However, tragedy struck the Apollo programme on 27 January 1967 when the three Apollo 1 astronauts were killed at the Cape in a flash fire within the capsule during a simulated countdown. Like all America, and indeed the World, Slayton was stunned. One of the dead astronauts was Slayton's fellow Mercury astronaut Gus Grissom.

On that tragic day shortly after the accident, in his office at the Cape, "shaking like a leaf" he called the three wives of the Apollo 1 astronauts [12], while trying to calm himself by unsuccessfully trying to smoke a cigar (upon his appointment to the astronaut team in 1959 he did not smoke at all).

Later that year Slayton was involved in the selection of a second team of scientist-astronauts. (This was followed in 1969 by a simple transfer of seven further astronauts from the USAF MOL project; no selection criteria was needed since they had already qualified for the USAF programme. Slayton therefore was not involved directly with their appointment to NASA).

The original seven. NASA first seven astronauts, selected in April 1959 for the Mercury programme. Left to right, M. Scott Carpenter, Jr., L. Gordon Cooper, Jr., John H. Glenn, Jr., Virgil I. Grisso Walter M. Schirra, Jr., Ala B. Shepard, Jr. and Donal K. Slayton. Grissom died the Apollo-Saturn 204 fir at Cape Kennedy on 27 February 1967.

NAS

Return to Flight Status

During the years 1968–early 1972 Slayton was preoccupied with the Apollo lunar landings, the beginnings of the Skylab programme and the birth of the Space Shuttle. Throughout the ten years since his grounding he maintained his fitness by continuous exercises and keeping up with the ever changing methods of astronaut training in an effort to get himself back onto the active flight roster and hopefully into orbit.

As the Skylab crews had been selected, he looked to the Shuttle for a chance, but this was still several years away and with plenty of young unflown astronauts around his chances seemed slim to say the least. And he still had to prove himself to the medics.

ASTP

Then in March 1972, exactly ten years after he was grounded, he received a clean bill of health and, following a comprehensive review of his medical status, was declared eligible for future manned spaceflights by NASA's Director of Life Sciences and the Federal Aviation Agency.

In May 1972 the Apollo Soyuz Test Project was born and observers took it for granted that Slayton would be on the American flight crew, as proved to be the case on 9 February 1973 when the American crew was named [13]. Deke Slayton was at last given another chance to get into orbit. Immediately he began an intensive training programme which meant he had to learn the Russian language and travel all over America and to the Soviet Union. The ASTP training programme lasted just over two years.

In November 1973 he participated in a two-week training programme in the USSR along with other ASTP astronauts and cosmonauts. Similar training programmes were also conducted in the USSR during June/July 1974 and April 1975.

The Flight

The ASTP flight began with the launch of Soyuz 19 on 15 July 1975 followed 7½ hours later by the American Apollo. The docking took place on 17 July with joint crew activities occurring over the next two days; the two craft undocked and returned to Earth, Soyuz on 20 July and Apollo on 24 July. Flown for one day longer than the Apollo 11 lunar landing (July 16-24, 1969) ASTP marked the World's first international manned space flight, the first time American astronauts and Soviet cosmonauts had flown together in the same docked craft. ASTP marked "a successful testing of a universal docking system and signalled major advances in efforts to pave the way for the conduct of joint experiments and/or the exchange of mutual assistance in future international space missions" [14].

Astronaut No 42

For America ASTP was the last use of the one-off spacecraft missions. Next would be the Shuttle still then over four years away. For full details of the ASTP mission see [15, 16, 17 & 18].

Deke Slayton had at last gained his space wings by becoming the 42nd American in space and the 76th person in space. ASTP Apollo was the 31st manned American space mission and the world's 58th.

His feelings on making orbit were best summed up during the Apollo launch phase while admiring the view when he radioed at T plus 9 minutes: "Man, I tell you, this is worth waiting 16 years for". [19]. During the subsequent conversation with President Ford following the historic link-up on 17 July, Slayton was asked if the World's oldest space rookie had any advice he might pass on to younger people who had hopes of flying in space. "Decide what you really want to do, and never give up till you've done it" [20] he said.

One day before re-entry Slayton was asked by a reporter at the NASA Mission Control Center, Houston, whether the flight had proved more strenuous or easier than he expected. He replied: "From a physical point of view, I haven't done anything my 91 year old aunt in Wisconsin couldn't have done equally well" [21].

Slayton in hospital

During the descent of the Apollo CM the crew were affected by a leak of nitrogen tetroxide, which can, if inhaled in large enough quantities, be fatal or cause severe disabling lung disease. But following extensive medical examinations and tests the crew were pronounced fit and given a clean bill of health. [22].

However, when it was announced on 19 August that Slayton would undergo exploratory surgery in Houston for a spot on his left lung, concern was raised that this may have been caused by the gas leak in the Apollo. Following surgery on 26 August, NASA doctors stated that the lesion was not the result of inhaling the gas, but had begun its development before the flight. Without the accidental inhalation of the gas and subsequent X-ray examinations the lesion might have remained unnoticed. Had it been discovered before the flight, it might have meant that he had to be replaced by his backup and not be allowed to make the flight. It would have robbed Slayton of his second and possibly last chance of getting into orbit.

The removed tissue, which was non-malignant, was wedge-shaped, containing the 4mm nodule [23].

Slayton had logged a total of 217 hours and 28 minutes in space and had accumulated a total of 138 revolutions of the Earth. He was the last of the "Original Seven" Mercury astronauts to get into orbit.

New duties

Following the ASTP flight and his return to full fitness Slayton returned to his duties as Flight Crew Director becoming involved with operational aspects of the Space Shuttle programme. In October 1975 he made a final visit to the Soviet Union as part of the closing ceremony of ASTP.

In early 1976 he became Deputy Director Flight Crew Operations for Shuttle Approach and Landing Tests (ALT's) [24] serving in this capacity until April 1978 when he became Manager for Shuttle Orbital Flight Tests (OFT's) scheduled to begin late 1979/early 1980 [25].

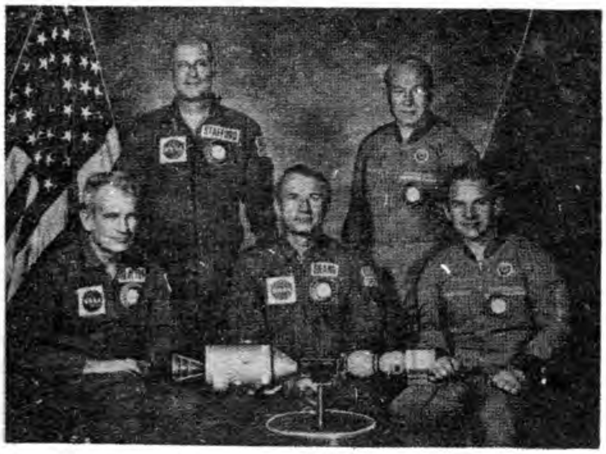
It was during his duties as Manager of ALT's that he participated on the selection board for the Group 8 (Shuttle Pilots only) astronaut-candidates. However, ALT duties precluded major participation in the Board's activities [26].

Slayton the man

At 51 Deke Slayton was the oldest man ever to make a first flight into space (the previous record being held by Soviet cosmonaut Lev Demin who was 48 when he flew on Soyuz 15 in August 1974. He finally proved to the doctors what he had been trying to tell them for years: "I was never ill, but it took me ten years to prove it to the medics" [27]. He currently is deeply involved with his latest responsibilities within the Shuttle programme even though it probably means that he will not make a second flight (although with the possibilities of a Shuttle Salyut flight in the making we may see Slayton back on the flight roster again).

Mike Collins has described Slayton as a "Super straight shooter, honest no-nonsense guy, the best boss I ever had" [28], and that his life and past career pointed to only one pinnacle in his life–that of Deke Slayton, Astronaut.

His physical description on entry to the astronaut gramme was: height 5 ft 10½ in; weight 160 lbs; brown hair (receding slightly) and blue eyes (his most prominent feature) [29]. By 1975 (September) he had grey hair and his weight had increased to 165 lbs [31]. It has been stated that Slayton is "blunt and early, but also thoughtful.He



ASTP Prime Crews. Astronaut Thomas Stafford (standing on left), commander of the American crew; Cosmonaut Alexei A. Leonov (standing on right), commander of the Soviet crew; Astronaut Donald K. Slayton (seated left), American docking module pilot. Astronaut Vance D. Brand (seated centre), American command module pilot, and Cosmonaut Valeri N. Kubasov (seated right), flight engineer of the Soviet crew.

NASA

doesn't wear his emotions on his sleeve, and his Scottish thrift shows up in an economy of words" [30].

His hobbies are like so many of the other astronauts in being outdoor activities, especially hunting, fishing and shooting. He also, of course, loves flying and had accumulated more than 5,200 hours flying time with 3,255 hours of that in jets.

Organisations and honours

Slayton is a member of the following organisations: Associate Fellow of the Society of Experimental Test Pilots; Fellow of the American Astronautical Society; Member of the American Institute of Aeronautics and Astronautics, the Experimental Aircraft Association, the Space Pioneers, and the Confederate Air Force; life member of the Order of Daedalians and the National Rifle Association of America; and honorary member of the American Fighter Aces Association.

He has been awarded three NASA Distinguished Service Medals and the NASA Exceptional Service Medal; the Collier Trophy; the SETP Iven C. Kincheloe Award; the General Billy Mitchell Award; and the SETP J H Doolittle Award for 1972.

He was also presented with an Astronauts Gold Pin by his fellow astronauts (following a secret vote of the entire group then in training) who sensed that he never really received any thanks for his "essentially thankless" job. When presented with the pin he gave a "brief but highly emotional speech. He was truly moved" [31]. Gold pins were awarded to astronauts upon the completion of a successful space flight. Unflown astronauts had a silver pin and at the time of his presentation Slayton had not flown in space.

As part of his work in the Mercury programme he co-authored several books on the programme with the other Mercury astronauts; these included:

We Seven, New York, Simon Schuster (1962)
Into Orbit, Time Inc, Cassell & Co Ltd (1962)
The Astronauts, Time Inc, Cassell & Co Ltd (1961)

Summary

As the American space programme moves into the age of the Space Shuttle, NASA's longest serving astronaut is right there with the new programme Deke Slayton has survived where others have been and gone. He holds great respect from his fellow astronauts and indeed from Soviet Cosmonauts and the whole astronautical community; hopefully we shall see him around for many years to come in the astronauts pool of activities, possibly getting another flight himself before retiring from NASA. He has at least another 10 good years with the agency and hopefully with a few more space flights to his credit as "America's Twenty Year Astronaut".

Acknowledgements

In the preparation of this paper the author wishes to acknowledge the assistance of the Astronaut Office, Johnson Space Center, Houston, Texas; official biographical data sheets supplied by, amongst others, Mrs I L Scott, Public Service Branch JSC, NASA; Marcia S Smith, US Library of Congress; and of course to Astronaut Donald K Slayton, for providing the subject material.

The following publications were also of immense help and freely consulted:

Spaceflight; Flight International; Aviation Week and Space Technology; NASA Activities; Buzz Aldrin's *Return to Earth;* Mike Collins' *Carrying the Fire;* and *First on the Moon;* also *Astronauts and Cosmonauts Biographical and Statistical Data* 1975; 1976; 1977 and 1978. The book *Seven into Space* by Joseph Bell 1960) was particularly useful.

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TOWARDS CITIES IN SPACE

By Tim Hassall

It is my opinion that the most important reason for astronautics is to provide new living space for man. Recent space probes have confirmed the view that, without "terra-forming" their surfaces none of the planets or their satellites in the Solar System is yet suitable for human life. Suggestions have been made that, for example, the atmosphere of Venus could be suitably modified [1]; however, this seems a task that might take millenia. Millenia may be too long to wait. Dyson [2] has pointed out that, even with modest growth rates in energy consumption the human race will want to consume the whole of the solar energy flux in a time scale comparable with the present length of written history [3]. Clearly, in order to avoid a Malthusian "dead end" [4] it will be necessary to "increase the total of productive forces as rapidly as possible". The only way for the human race to do this indefinitely is to move into space, where the energy flux from the Sun, or other stars, can be used directly. Probably the first person to publish this idea was Tsiolkovsky [5].

I first became aware of these ideas through reading *The Exploration of Space*, by Arthur C Clarke [6], which led me on to Bernal's essay *The World the Flesh and the Devil* [7]. Bernal's book was out of print for many years, although it was possible to obtain it through the British public library system. Bernal maintained, among other interesting ideas, that humanity would use the material in the asteroid belt to construct living space, and that, eventually, such habitats could be used to migrate to other solar systems.

The person who has done most to publicise the idea of making space habitable is Professor O'Neill, [8], [9] and [10]. He seems to have inspired quite a movement, including the *L-5 Society* [11] and writers such as Heppenheimer [12]. For the serious student there is *Space Settlements a Design Study*, published by NASA [13]. Science fiction writers have not lagged far behind the more adventurous engineers and scientists. Thus Larry Niven in *Ringworld* [14] and an article in *Analog* [15] has disseminated Dyson's ideas, while in his novel *Colony* [16] Ben Bova has done the same for O'Neill.

For every action there is a reaction, for every thesis an antithesis. The case *against* space colonisation has been ably put by Holt in the Co-Evolution book *Space Colonies* [16].

One of the most attractive features of O'Neill's "Island" space habitats–the illusion of the Sun's trajectory across the sky, was to be provided by means of three hinged mirrors. These were to be placed round the axis of the cylindrical habitat at 120° intervals. By swinging these mirrors out through 90° it should be possible to reflect sunlight into the habitats through an angle of 180°. However, as Holt points out, the strengths of currently known materials are insufficient to construct such a system for rotating habitats with the periods and dimensions contemplated by O'Neill.

In a reply to Holt [16], p.63, Heppenheimer suggested that it would be possible to build the mirror assemblies as fixed structures, and then to tilt the mirrors on them. Holt rebutted that even so the interior of a large space structure would in no way look like the natural environment of the Earth's surface.

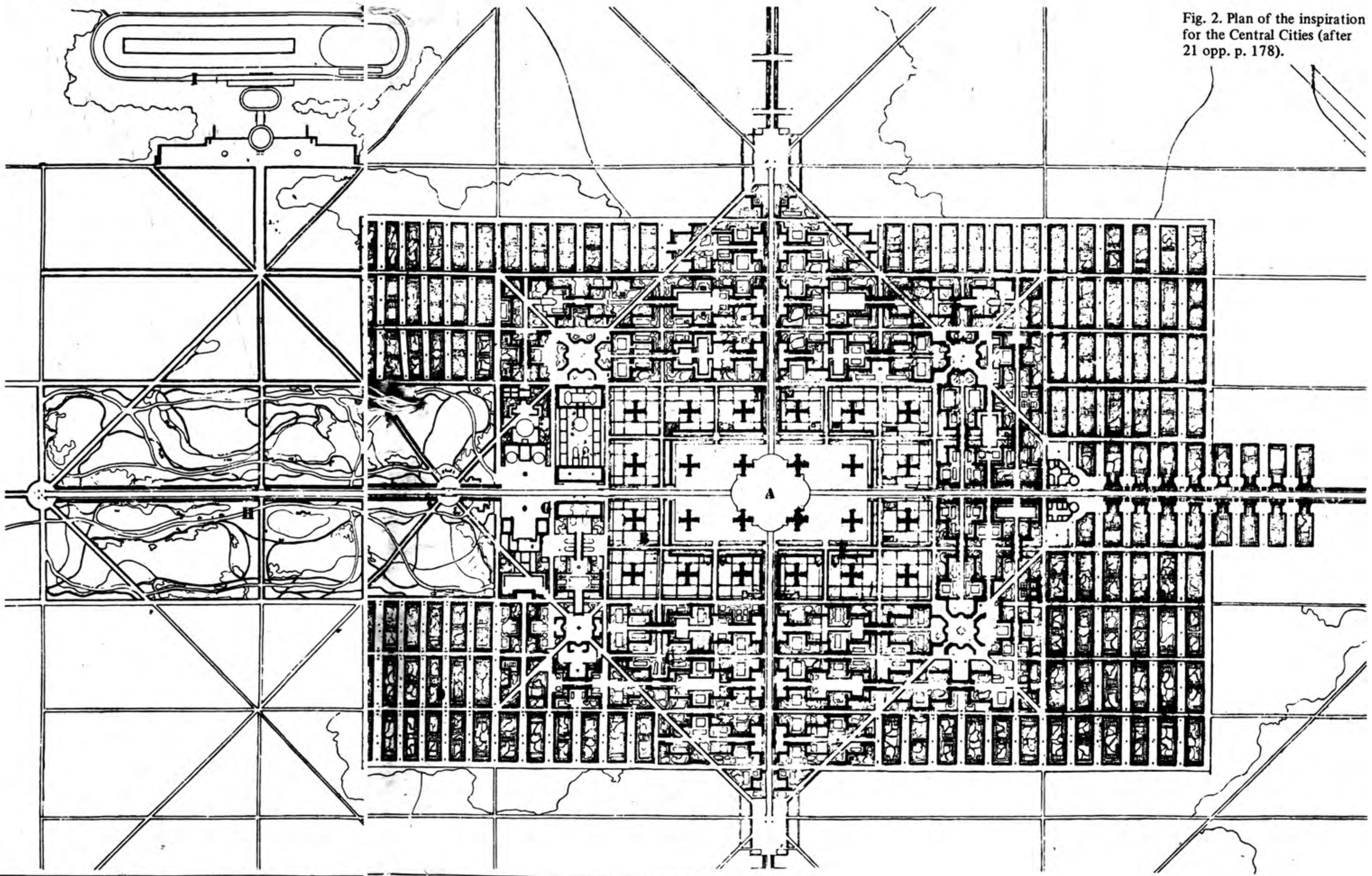


Fig. 2. Plan of the inspiration for the Central Cities (after 21 opp. p. 178).

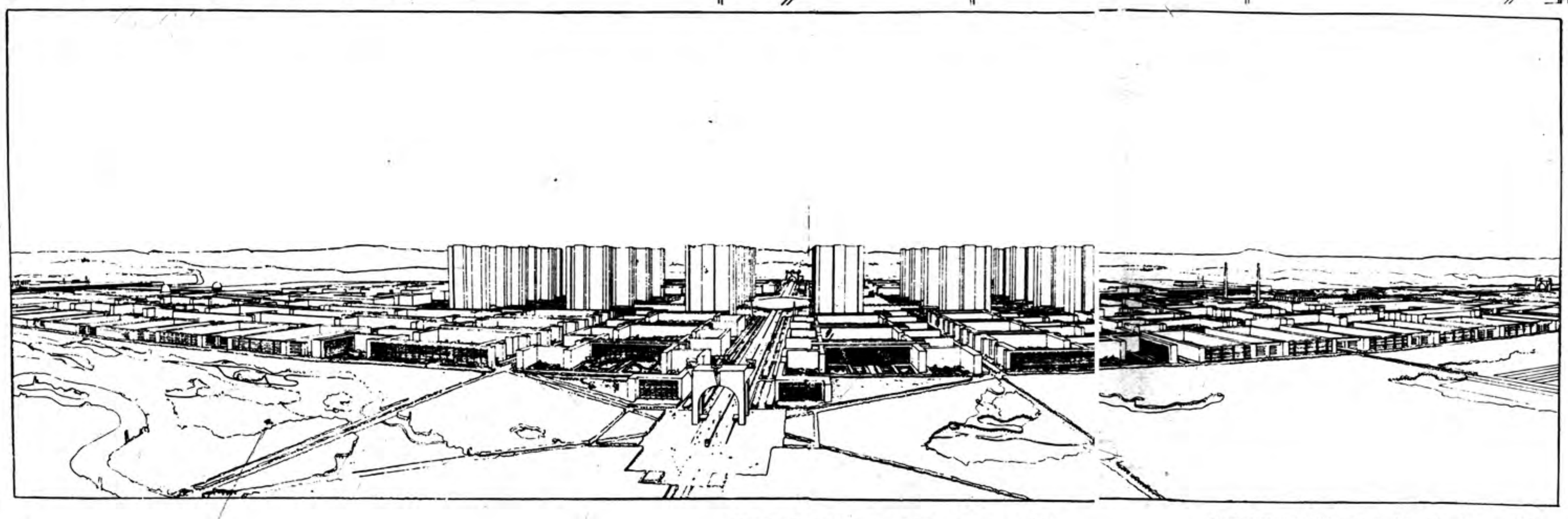


Fig. 1. Panorama of the inspiration for the *Central Cities*, inspired by *A Contemporary City*, (21 pp 190 & 191)

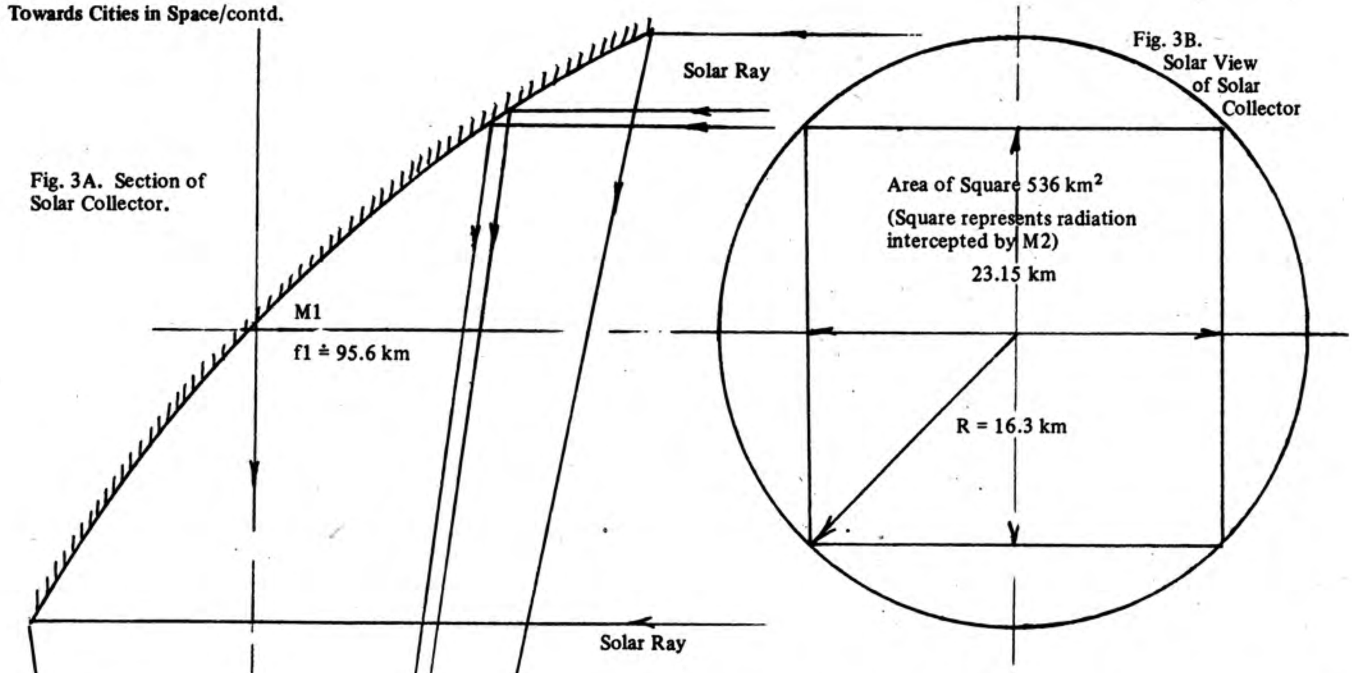


Fig. 3A. Section of Solar Collector.

Fig. 3B. Solar View of Solar Collector

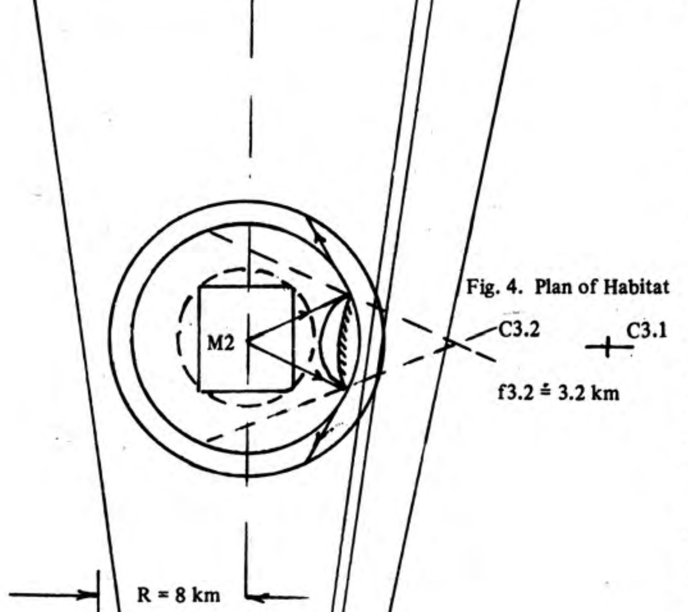


Fig. 4. Plan of Habitat

This article is an attempt to go some way towards meeting the challenge issued by Holt. I have a strong gut feeling that within the next millenium the vast majority of the human race will come to live in cities in space. To my mind this movement has all the characteristics of what Cornforth [17] calls a "prediction which is also a statement of intent".

This is not to mean that I do not agree with many of Holt's sentiments regarding the necessity of investment for changing conditions on Earth. However, here also, as I have made clear elsewhere [18], space technology could play a crucial role.

For basic sociobiological reasons [19] man will expand to fill the living space available. Since the living space on the Earth's surface is limited, new living space must be found elsewhere, beneath the surfaces of the planets and satellites of this or other solar systems, or by artificial construction in space. Within the framework of present knowledge the only way to provide a pseudogravity is in the form of the reaction to the centripetal force of a rotating vessel. Hence, for people* with the physiology of Terrans, a rotating artificial habitat is preferable to any known extraterrestrial body.

*And plants. *Note added in proof.* [32].

Fig. 5. Section of Habitat

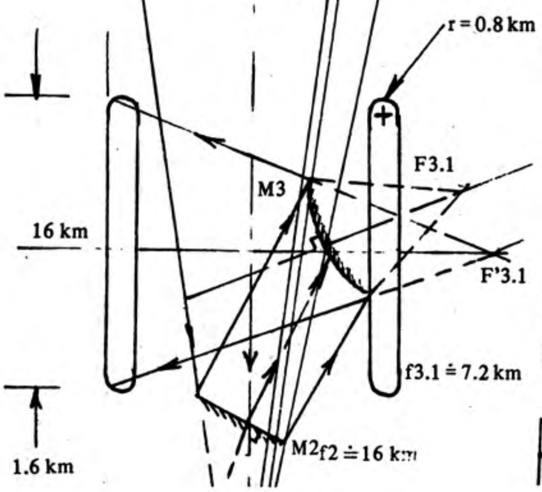
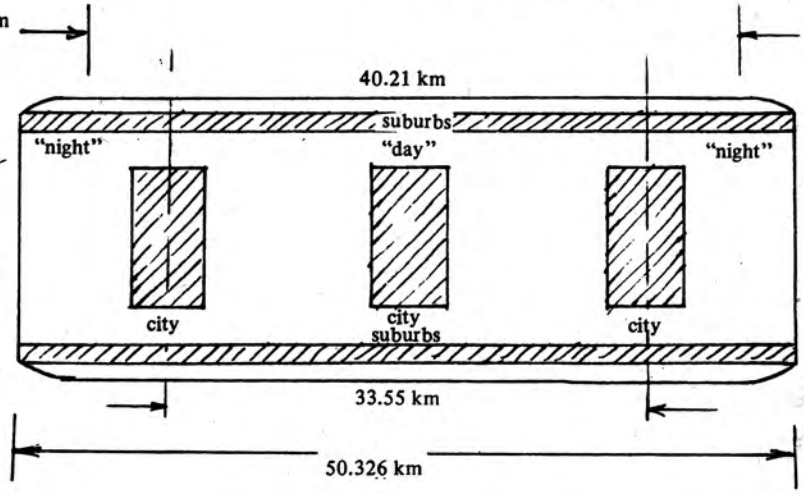


Fig. 6. Development of Habitat



That this is the way to go is shown by the fact that the relatively accessible material of the asteroids has been calculated as being able to provide perhaps 3,000 times the surface of the Earth, in the form of space settlements [20].

The problem then is: "Is it physically possible, within the bounds of present day knowledge, to construct a city, with a fairly Earthlike environment, in space?"

The city should, for the purposes of this article, *look* like a city, not like the living quarters of a submarine or troopship. Since, at least when it was first established, one would expect a space city to be fairly isolated—even radio messages would take more than half an hour to get from the orbit of Jupiter to Earth—and; within the framework of present knowledge private interplanetary spacecraft seem likely to be comparatively rare; for the full cultural development of each inhabitant of the space city, it will be necessary to design for a rather larger population than most of the literature suggests. New Zealand, with 3 million people, is able to support seven universities. Nevertheless some travellers from other parts of the Earth claim that New Zealand culture is insufficiently diverse. Therefore, it was decided to design for a habitat capable of supporting 9 million people. The "Contemporary City" of Le Corbusier [21], Figs. 1 and 2, was chosen as the paradigm of a city for this problem.

It will be necessary for there to be a sufficiently large agricultural area. From *Space Settlements a Design Study* it appears that with the best present day practice the area needed for crops and animal husbandry would be about 50 m^2 per person [13] p.26.

It would be necessary for the habitat to be able to provide as full a range as possible of terrestrial outdoor activities.

The habitat should have a pleasant climate, with Earth-normal sea-level atmosphere, gravity, and as close an illusion as possible of the terrestrial solar trajectory. The habitat should be well shielded from radiation and should be dynamically stable.

Amount and Use of Habitat Projected Area

The size of the habitat is dictated by the number of people and the amount of projected area each person requires.

In the "Contemporary City" design the central city, with an area of 16 km^2 provided living space for 1.2 million people—600 thousand in the skyscrapers of the city core and the balance in the medium rise blocks of the inner city [21] p.172. In my design it is assumed that the remaining population would be housed in two *linear cities* [22], each 1 km wide and about 50 km long. Three central cities (one for each time zone, eight hours apart) give a population of 3.6 million on 48 km^2. The remaining 5.4 million people are housed on 100 km^2; following Le Corbusier's ideas they could be housed in *Unités d.Habitation* [23] pp. 208 to 219, blocks 50 m high, and 150 m long, each containing up to 700 four-person family homes, Fig. 7. The total housing area is then 148 km^2 for the maximum 9 million inhabitants.

The required minimum agricultural area, using the *best* current agricultural practice, is estimated in *Space Settlements a Design Study,* [13] p.26, Table 3-2, as 49 m^2 per person, not counting area required for agricultural processing, assumed to take place in basement industrial areas, beneath the central cities.

Allowing 50 m^2 agricultural area per person, 9 million people need 450 km^2 of agricultural surface for staple foods. (It is assumed that luxury items, such as coffee and chocolate, would be grown in subsidiary habitats adjacent to the main one. This would be practical since the interchange of biomass and plant nutrients would be small for these crops). The minimum total area needed for 9 million people is thus a little less than 600 km^2.

Shape of the Habitat

In the *Appendix* it is shown that it is structurally possible to construct a space habitat in the shape of a hollow cylindrical shell, or torus extended along the axial direction, 16 km in diameter, 16 km long, with semi-toroidal edges 1.6 km in diameter, Figs. 4 and 5. The calculations were performed assuming "Earth Normal" pseudogravity and atmospheric pressure and with an internal loading of 500 tonne mass per m^2 (equivalent to a tower block 250 m. high, and twice as dense as water). It was assumed that the structural material was vapour-deposited aluminium [13], p. 69, Appendix E, and it was assumed that this had the same properties as cold-formed aluminium wire or plate [13], p.63, Table 4-4, because the properties of vapour-deposited metals and alloys are "true engineering materials" with the properties of rolled and annealed sheet [24]. The equations used in the structural calculations were for a torus, which is the limiting case of the shape proposed; Timoshenko and Young [25] p.23, encourage belief in the assumption that it is possible to use structural equations developed for a torus for the shape proposed. The value obtained for the thickness of the structural outer wall is 0.183 m. of cold worked aluminium.

In Fig. 6 the disposition of the land use areas is shown. It is assumed that all the land between the outer limits of the two suburban strips is given over to housing, agriculture, transport and recreation; this area is equal to 50.326 x 14.4 = 724.7 km^2. Deducting the 600 km^2 already calculated leaves a little more than 124 km^2 for recreation and internal transport (chiefly the equivalent of "Farm Roads").

Assuming that the latter take up about 60 km^2, 64 km^2 would be left for outdoor recreation. Note that this is in addition to the recreational areas *within* the urban regions, which is considerable, and also the area of the curved end caps. It is therefore assumed that most of this 64 km^2 would be in the form of lakes for water sports.

The areas of the two end caps (approximately 126 km^2) would be left as wilderness recreation areas, for the following reasons:

First, such areas have aesthetic appeal.

Second, recent work [26] suggests that the whole biosphere may comprise one gene pool, i.e. that hereditary material may be constantly interchanged between animals, plants, etc. Hence it may be vitally necessary for the genetic fitness of our species to be in contact, via appropriate vectors, with as many different ecologies as possible. (One could speculate, for example, that male mosquitos, which parasitize plants, obtain plant genes, via virus carriers. This genetic material is then transferred by female mosquitos and other viruses to human beings. For all we know at present such an interchange is an important mechanism in the development of our defence mechanisms against infectious diseases, which, like the common cold, are in a constant state of evolutionary flux.)

Third, examination of Fig. 5 shows that part of the rim area is not insolated. This is deliberate. It represents the steeper part of the rim area, local slope from about 30° to vertical, and is intended to simulate the conditions for the condensation of water on the mountains of Earth, i.e. I hope that it would snow in these regions, to provide ski fields, and to assist in the habitat's hydrologic cycle.

The Habitat Optical System

This was inspired by the coelostat, projected for astrogation in the 1930's BIS cellular lunar spaceship and for astronomical observations from the Ross and Smith Space Station design [27] face p.74, Plate X.

Sunlight is reflected onto the inner surface of the habitat by means of a system of three mirrors.

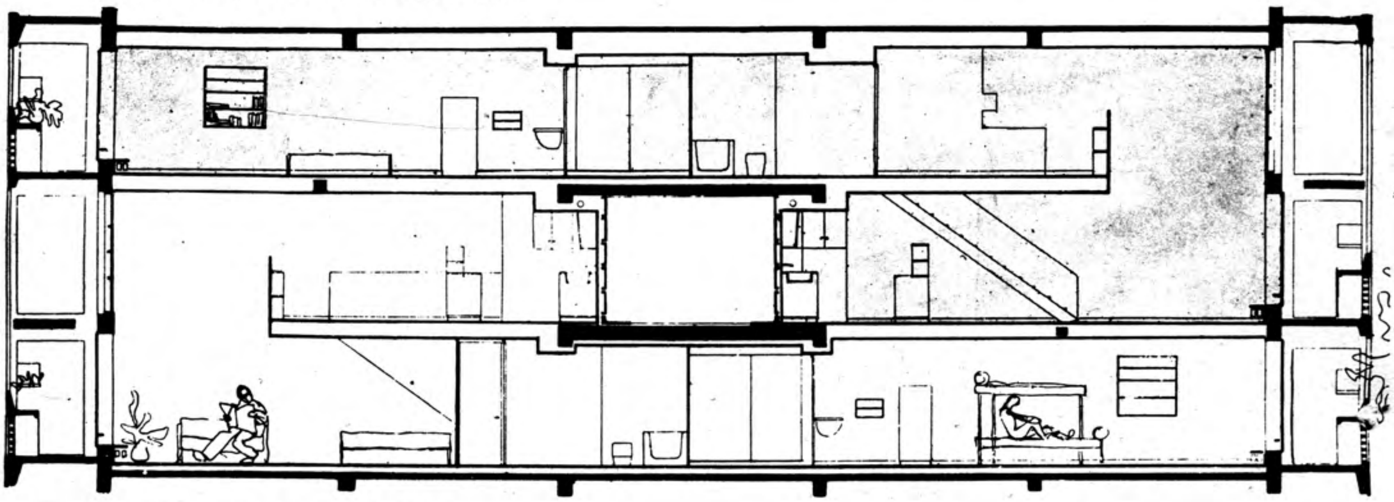
M1, The Solar Collector, Figs. 3A and 3B, is of elliptical planform and parabolic section. It is maintained with its principal axis at 45° to the plane of the habitat's orbit round

Fig. 7. Arrangement of a *Pair of Flats* in a *Unite d'Habitation* (23 p 211)

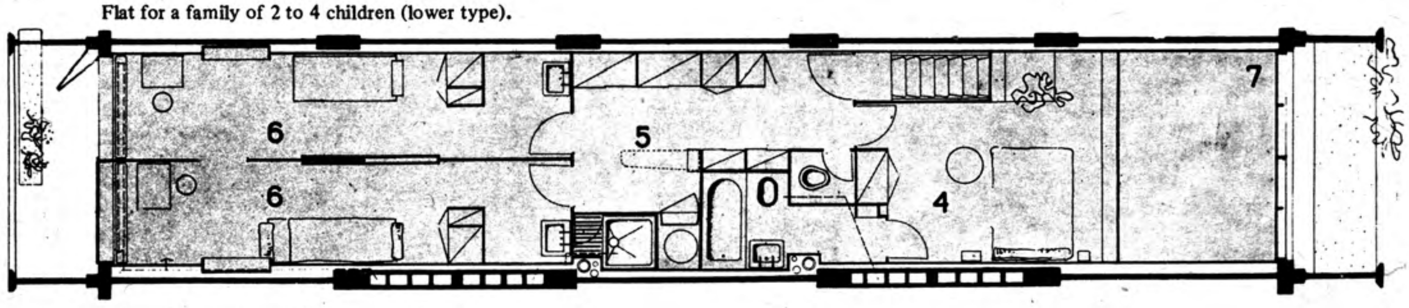
1. Corridor to service flats
2. Flat vestibule
3. Open plan living room and kitchen
4. Master bedroom with adjoining bathroom
5. Laundry area with airing cupboards, ironing board and children's shower
6. Children's bedrooms
7. Upper part of living room

Longitudinal section through a pair of flats. A corridor divides them.

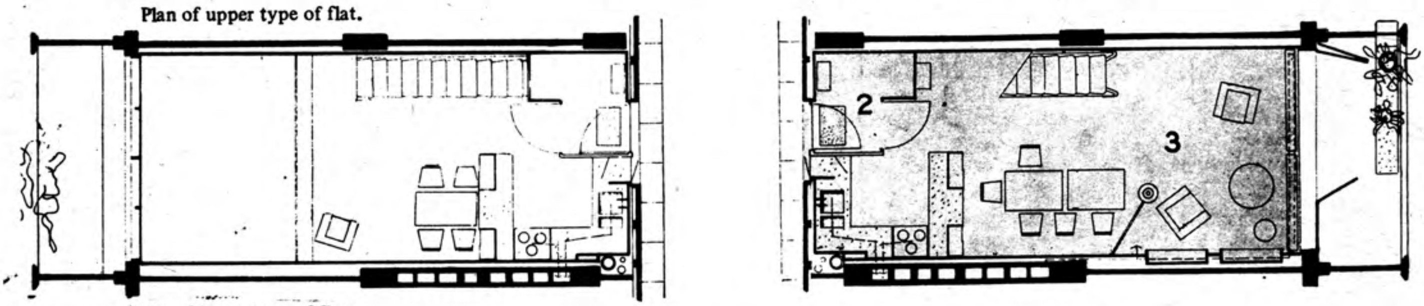
Flat for a family of 2 to 4 children (upper type).



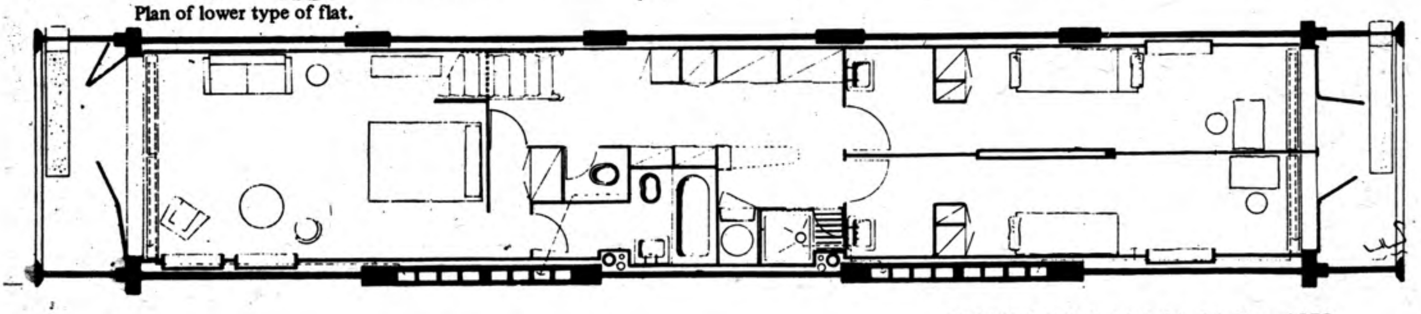
Flat for a family of 2 to 4 children (lower type).



Plan of upper type of flat.



Plan of lower type of flat.



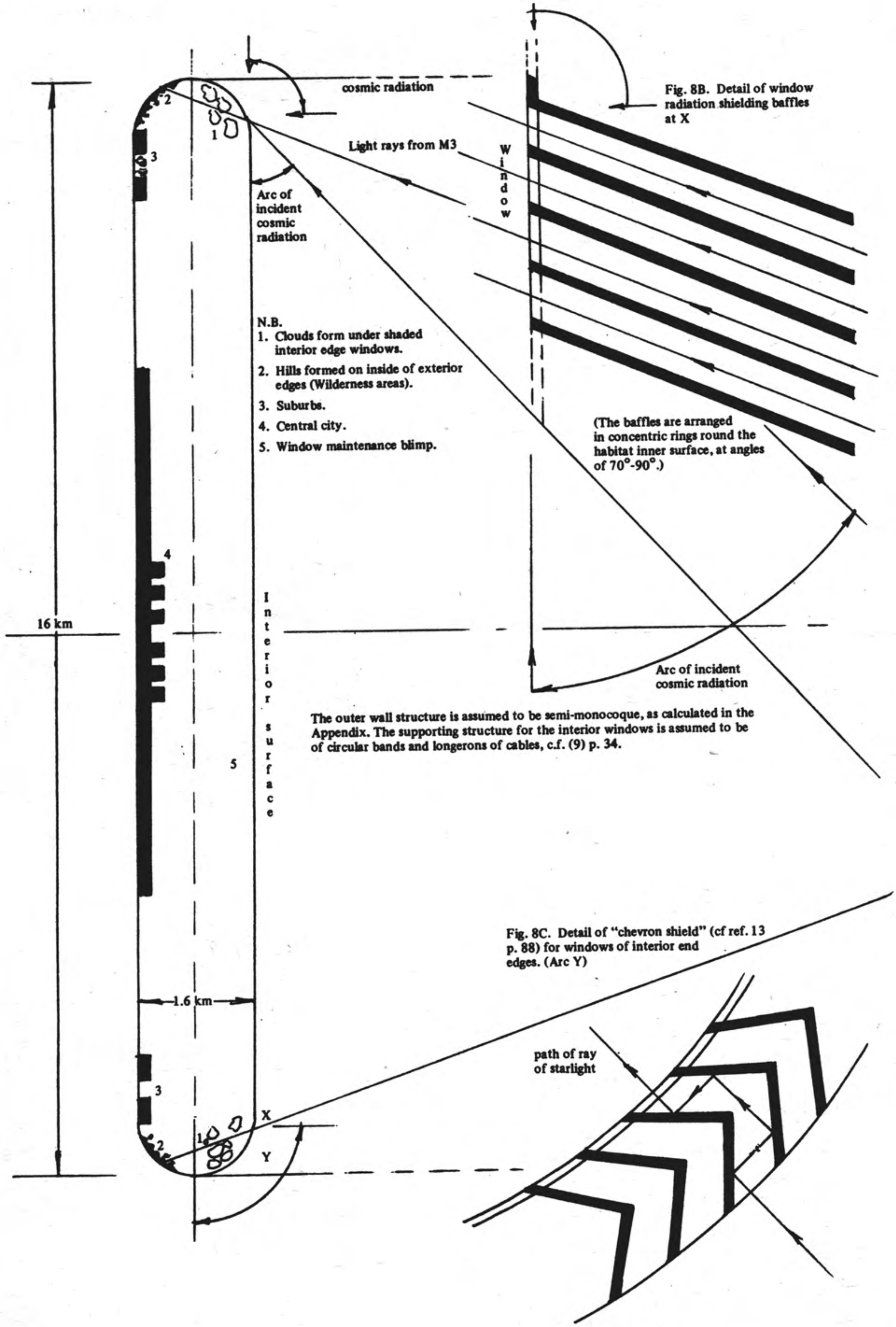


Fig. 8B. Detail of window radiation shielding baffles at X

The outer wall structure is assumed to be semi-monocoque, as calculated in the Appendix. The supporting structure for the interior windows is assumed to be of circular bands and longerons of cables, c.f. (9) p. 34.

Fig. 8C. Detail of "chevron shield" (cf ref. 13 p. 88) for windows of interior end edges. (Arc Y)

the Sun. The projected area of the collector, facing the Sun, is larger than the projected area of the habitat to be illuminated. This area is here taken to be two-thirds of the inhabited surface of the habitat. This is so that the habitat can have 16 hours "day" to eight hours "night". This area is approximately 536 km^2. M1 can be maintained in shape by means of thin shrouds like those of a parachute. These could be attached to a rim, not shown in the diagram, mounted on low friction (e.g. magnetic) bearings inside the habitat's inner cylinder, and driven so that the collector was always correctly aligned with the Sun. The size of M1 shown is for a habitat at about 1 astronomical unit from the Sun. For other orbits its linear dimensions would have to be altered proportionately. For example, at the orbit of Jupiter they would have to be 779/150 times those shown in the Figures. The focal length of M1 is determined by the size of M2, so that in this case it is approximately 96 km. It would be very important to keep the reflected image of the Sun from M1 accurately centred on the axis of the habitat. If this were not done, the image of the Sun in the "sky" of the habitat would oscillate about its trajectory, destroying the illusion, and perhaps causing disturbing medical side effects.

M2, The Second Mirror, Figs. 4 and 5, is a parabolic convex mirror. It is mounted with its pole exactly on the axis of the habitat, on a hub (not shown). The hub could be fixed to dished spokes, similar to those of a bicycle wheel. M2 is driven so that the light reflected from it travels once round the inner surface of the habitat every 24 hours. M2 should be made as small as possible, the limiting factor being the heating effect due to the large amount of energy incident on it. Here it is assumed that about 0.95 of incident radiation is reflected by M2; hence it has been dimensioned at 0.05, the projected area of the main mirror M1.

The focal length of M2 is chosen so that rays are reflected from it in a parallel beam. This is managed by having the focal length of M2 the same as the distance behind the pole of M2 as is the point to which the rays from M1 are focussed, in this case about 16 km.

The principal axis of M2 is at somewhat less than 22.5° to the axis of the habitat. This causes the central ray from M1 to be reflected through somewhat less than 45°, so that it strikes the pole of M3. M2 could be adjusted to produce seasonal variations, either by having removable cutouts, to reduce the amount of reflected radiation, or by altering its angle. In the latter case, not only would there be a seasonal variation in the illusive Sun angle, but also one end of the habitat would have summer while the other had winter. This might be necessary on ecological grounds (e.g., winters perform a function in that they reduce agricultural pests), but my preference would be for a constant tropical climate.

It will be noted that M2 has a rectangular planform. This is so that the terminators in the habitat shall be parallel with the axis of the habitat. Since the corners of M2 sweep out circles about the habitat's axis it is necessary for M1 to be elliptical. Hence some radiation is reflected down the axis of the cylinder without being used for "sunshine". It is suggested that this energy should be collected at the edges of M2, and used, for example, to drive M2. Similarly, if M2 had to be cooled, some of this energy could be so used.

M3, The "Pseudo-Sun Mirror", Figs. 4 and 5. This convex mirror, of about the same area as M2, is mounted on the inner wall of the habitat. It rests on low friction (e.g. magnetic) rails, and is driven round the habitat once a day. It has a rectangular planform and double curvature, so as to illuminate two-thirds of the interior of the habitat at any time. It is important that it be driven synchronously with M2. All three mirrors would probably have to be controlled by means of laser beams and a computer system to ensure sufficient accuracy.

The Windows would presumably be of the "chevron shield" type, Fig. 8. Note that an internal pressure of 1 atmosphere means that the centrifugal stress due to 10 tonne/m^2 of shielding is off-loaded.

Conclusions

It appears that the problem as stated has been solved; it is indeed physically possible to build cities in space with an environment close to that of the Earth.

Of course a large number of problems still have to be resolved; for example, the overall heat balance of the habitat, the weather in a volume with a ceiling and gravity gradient as well as Coriolis effects. Window maintenance presents a difficulty. Perhaps they could be cleaned by a sprinkler system which also provides artificial rain. It would be easily possible for a small airship, with an upper cockpit, like the gunner/observer's position on the World War 1 Coastal Class blimp, to fly up to the roof to keep the sprinkler heads in good order.

One may wonder where the technology would come from to build such large habitats. Presumably raw materials can eventually be obtained from small airless bodies by magnetic launching, as described by O'Neil *et al.* This would account for aluminium, oxygen and rock. If the habitat was located in an orbit near to a giant planet, carbon, nitrogen and hydrogen [31] could be obtained by similar, but less expensive means, to those outlined for helium^3 procurement in the *Daedalus Project* [28].

The technology for the construction of large scale structures by vacuum vapour deposition might well be developed in an intimate way with attempts to communicate with and travel to other solar systems. For example, one could imagine that vacuum vapour construction techniques will involve the use of large solar-powered laser beams, to accurately vapourise large quantities of rock and/or aluminium. Exactly such powerful lasers have been suggested for signalling by stimulated stellar emission [29] and for laser powered interstellar rockets [30].

Thus it appears that space colonisation will proceed in a dialectical fashion, hand in hand with interstellar technology. It is my firm conviction that such technology is no more ahead of what we have to day than is the Concorde airliner compared with Henson's "Aerial Steam Carriage" project in the middle of the last century.

Appendix

Table 4-7 *Space Settlements a Design Study* [13] p.66, gives formulae for the structural masses of various configurations of space habitat. The same reference, Figs. 4-19, (p.67) shows that a torus will have a lower mass per projected habitable area than either a sphere or a cylinder with spherical end caps. According to Tables 4-7 of ref.13 the structural mass of a torus with a ribbed skin is given by:

$$\text{Mass} = 4\pi^2\, GR^3\eta \left(\frac{(P_A\eta/2 + (\Gamma/\pi)}{\sigma - GgR} + \frac{P_A\eta}{\sigma} \right)$$

Where
- G = density of structural materials
- R = radius of rotation
- σ = working stress
- P_A = atmospheric pressure
- Γ = internal load
- g = pseudo gravity
- η = torus aspect ratio

Examination of this equation shows that the working stress

must be greater than the value of GgR, otherwise the mass becomes infinite. This fact can be used to calculate the maximum value of R:

$$R_{max} < \frac{\sigma}{Gg}$$

Taking σ = 234 MPa = 2.34×10^8 N/m^2, from Table 4-4, p.63 of ref. 13 for cold formed aluminium plate,

and $G = 2.65 \times 10^3$ kg/m^3 from the same source,

for a pseudogravity of

g = 9.81 m/s^2, i.e. terrestrial normal, then

R_{max} must be less than 9 km. (9 001 m).

It is now possible to calculate the surface density of the torus (Mass/Surface Area), for different loadings.

e.g. If $P_A = 10^5$ N/m^2, which is Earth normal

$\frac{\Gamma}{g}$ = 500 t/m^2 = 5×10^5 kg/m^2, i.e. represented by a tower block 250 m high, and twice as dense as water

R = 8 km = 8×10^3m (implying axial rotation of period 179.4 s)

Then, from the quoted formula,

$$\frac{\text{Mass}}{\text{Surface Area}} = R\left(P_A\frac{\eta/2 + \Gamma/\Pi}{\sigma - GgR} + \frac{P_A \eta}{\sigma}\right)$$

$$= 8\times10^3\left(\frac{10^5 \times 0.1\times0.5 + (5\times10^5/\pi)9.81}{2.34\times10^8 - 2.65\times9.81\times8\times10^6} + \frac{10^5\times0.1}{2.34\times10^8}\right)$$

This gives a value of 484.6 kg/m^2, which would correspond to a thickness of 0.183 m. This thickness of aluminium would not provide anything like the radiation shielding provided by the atmosphere; according to ref. [13], p. 44, this is approximately equivalent to 10 t/m^2. However the mass loading chosen, of 500 t/m^2 is ample to allow for shielding in the form of lakes, subsoil, etc., within the habitat.

Following the reasoning of ref. 13, p.66, where a sphere is considered to be the limiting case of a cylinder with spherical end caps, it is considered justifiable to consider a torus as the limiting case of a double walled cylinder with toroidal end caps. The element of the torus outer surface which is in the plane of symmetry of the torus will be the element subjected to maximum stress. The loadings perpendicular to the plane of rotation of this element will be the same as the axial loadings on any element of the cylindrical portion of the outer surface of the extended double walled cylinder. The hoop stresses and circumferential stresses will be the same for the most stressed element of the outer surface of the double walled cylinder.

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SPACE AND THE U.S. AIR FORCE

Introduction

Earlier this year General Alton D. Slay, commander, Air Force Systems Command, Andrews Air Force Base, explained the United States Air Force initiatives in space. He was addressing the AIAA Annual Meeting in Washington, D.C.

After stating that "just under a billiòn US dollars had been spent each year for the past several years on space systems and space R & D, and that some two billion US dollars was "in our space budget this year," General Slay said it was necessary to understand that the 'real' mission in space may be here on *terra firma.*

Data Streams

"We generally make use of space today through data streams—data streams which are highly important to our combat missions for command and control; for communications; and for information gathering. This use of space—for command and control for communication and for information gathering—is just a logical extension of something we've been doing for centuries, elevating our "eyesight" above the terrain to control a force, find things, or to communicate.

"We've certainly done a myriad of exciting things in space and have seen many great technology advances. The forecast is for more of the same.

"But the Air Force does not develop space systems just because they are exciting or technically challenging, or because space is our last frontier," General Slay continued. "Space systems are very, very expensive and must be able to pass the acid test of providing a significant contribution to the effectiveness of our combat forces; and our combat forces are today's terrestrial forces.

"Our current space systems acquire data, store the data as necessary and then at the appropriate time, transmit the data to ground links on Earth. The degree of utility of the space system depends upon the relative importance of the data in the data stream and the contribution it makes to our terrestrial forces.

"We have a number of space programmes that are currently providing us with very diverse but extremely important data streams.

"Knowledge of weather and weather systems has always played an important role in military operations. It still does and will continue to do so as far as I can see into the future.

"The Defense Meteorological Satellite Program (DMSP) is one of the most important gatherers of atmospheric and space environmental data available. We will most certainly continue to take full advantage of satellites for this mission.

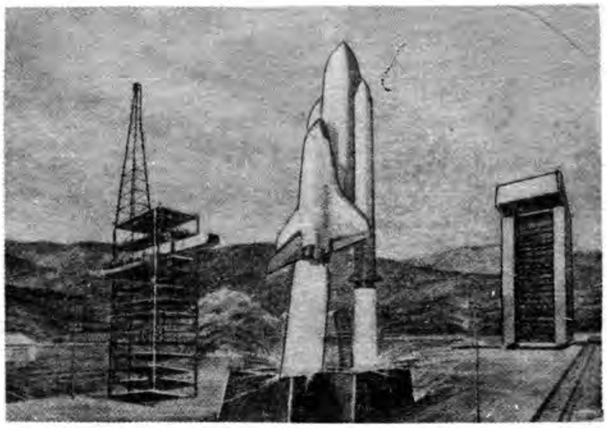
"We rely on "elevated surveillance" space systems for a portion of our tactical warning requirements to ensure the survivability of our strategic forces. The key to the protection of our strategic systems is early detection of an enemy offensive nuclear strike. Although our ground systems offer us a degree of protection, their limited line of sight is a crucial disadvantage when time, measured in minutes, is of the utmost importance."

"Our space warning systems complement our ground based systems and offer greater detection range and coverage," said General Slay.

"We will continue to use space systems for this purpose. We will, in fact, expand our use of space based warning systems.

"We have used space based systems for navigation for many years. In fact, the Sun and the pole star, Polaris, have been used for navigation for centuries.

"If I remember correctly, it has always been an old Navy saying that "The price of good navigation is constant vigilance." We have a space based navigation system—the NAVSTAR Global Positioning System—which just might change that old adage, and greatly reduce the need for 'constant vigilance.' NAVSTAR, or GPS, provides a survivable, world-wide grid reference system available to users on land, sea, in the air, or in space.



WORLD SCANNING. Beginning in 1983-84, Space Shuttles will be launched into polar orbit from Vandenberg Air Force Base, California. These polar orbital missions will add a new dimension to space flight, permitting man, for the first time, to view the entire Earth as it turns beneath him.

Rockwell International

"The system itself, when fully implemented, will consist of 24 satellites in three orbit planes. It will provide direct line-of-sight signals continuously from at least four satellites to all users throughout the world. These signals will enable very precise positioning of aircraft, ships, jeeps, people walking, or orbiting spacecraft.

Communications

"Reliable communications are the heart of all military operations. If one cannot communicate reliably, one cannot control a force.

"Today, we rely heavily on space based communications relay systems to ensure quick, reliable communications throughout the world. Our overseas forces are now only seconds away from being fully cognisant of a decision or direction by the National Command Authorities.

"The Air Force Satellite Communications (AFSATCOM) system provides satellite communication links for transmission of emergency action messages from the NCA to our strategic forces throughout the world and provides a force management capability as well. This space based system is critically important to our strategic deterrent posture.

"The Satellite Data System (SDS) is a major part of the AFASATCOM system. It services the strategic forces with critical two-way, transpolar, ultra-high frequency communications. The SDS also provides high data rate communications for the Air Force Satellite Control Facility by interconnecting remote tracking stations and the Satellite Test Centre.

"The Defense Satellite Communications System (DSCS) is the key element for world-wide long haul communications. DSCS is of particular importance in a crisis environment, as it has been providing world-wide communication support for theatre operations for several years. We are now

in the R & D phase for the third generation DSCS.

"When fully deployed, the system will have four operational satellites in synchronous orbit with two on-orbit spares. The all up system will provide, in addition to support for theatre operations, long distance communications for intelligence, warning, and other special user requirements.

"For the future, I see no diminishment of the utility of space for communications and data relay," said General Slay. "I see only expansion."

"Obviously, we make use of space for photo reconnaissance. So do our potential adversaries. These are satellites which are not only highly useful to us but, for some purposes, are absolutely essential to our national well being.

"We will continue to use space for this purpose as far as I can see into the future. To do otherwise would be the height of national folly."

Space Shuttle

"What about the so-called 'Shuttle Era?' What about the coming 'Age of the Space Transportation System?' Some will claim that it will cause a new 'space revolution' and will bring new and exciting space missions for us. Without any doubt, Shuttle will bring new challenges and new capabilities requiring much innovative thinking.

"The Air Force today is deeply involved with NASA in the Space Transportation System and we are working hard to achieve a reliable transition from expandable launch vehicles for DoD spacecraft to the reusable S-T-S.

"The Air Force currently buys and launches all DoD space boosters on expendable boosters. In the 1980 time period, we will start transitioning to the shuttle which will have the capability to support all current and planned DoD space systems.

"Shuttle is a real breakthrough in the method of placing space systems into orbit. It can place into space more than twice as much payload weight and three times as much volume as can a Titan III booster.

"This increased capability will allow us to rethink our en-entire approach to satellite system design.

"Today we live with very stringent weight and volume constraints just due to booster capability. With the extra capability of the Shuttle, we will be able to build cheaper but larger spacecraft; or we can add additional subsystems or systems for redundancy to attain longer satellite life, thus requiring less frequent replacement.

"We will also be able to add a variety of sensors and other devices on a particular satellite to support other missions in addition to the satellite's primary mission.

"One of the most important advantages of the shuttle will be the opportunity to enhance the survivability of our satellites. We are now addressing the various methods of doing that.

"By adding propellant, satellites can be manoeuvred a number of times. This compounds the problem for any anti-satellite weapon and will give us a new tool to protect our space assets.

"There are a number of other alternatives for survivability that Shuttle opens for us. We can proliferate our space systems by making them smaller, cheaper and of single purpose. We can carry decoys to confuse—or spare satellites that will not be activated until needed.

"The early flights of the shuttle will concentrate on satellite replacement; however, we will have the capability to bring a satellite back to Earth if some malfunction were to occur during lift-off or prior to separation.

"As we gain more experience with the Shuttle, we will be able to modify our satellites so they can be easily recovered from a low Earth orbit. This will give us the opportunity to reuse expensive satellites and update them as various technologies mature. The next step will be to service satellites while they remain in orbit. Construction of large space platforms might now be technically and economically feasible if a mission for such platforms is found.

"The shuttle certainly offers us many, many options and represents a giant step forward in expanding the use of the entire space arena.

"Some view the Space Transportation System as opening up a new era for further exploitation of man in space. There have been many arguments put forth on the advantages of having man as the key ingredient in our future space systems. We certainly have not built a machine that can substitute for the human brain and its ability to reason. But the Air Force has, since the beginning of the Space Era, developed a multitude of technologies that have allowed our space systems to accomplish their assigned tasks *without* man in space.

"Why? Introducing man into the loop has some disadvantages as well as advantages. One of the major disadvantages is cost. Man-rated systems are exceedingly more expensive than non-man-rated systems.

"Certainly Shuttle will have men aboard to pilot it and to perform the necessary tasks related to placing spacecraft in orbit, recovering them, or repairing them. These tasks alone will provide many more jobs in space for men—or for women for that matter. Also, there will obviously be manned experimentation in space such as both we and the Soviets have done for well over a decade. But will we evolve totally new and different missions in space for man beyond these obvious ones?

"There is a big question mark here. My bias lies somewhere between "possibly" and "probably." I'm just not sure. Other people are, so perhaps I'm just not enough of a visionary.

"One thing I strongly believe is that we do *not* need a series of large military manned space stations where we will continue to do the things we can do just as well with unmanned systems.

"We know that we can put people into space and support them reliably. But to put military people in space just because it's something we can do is not my idea of a judicious expenditure of our scarce resources.

"We must be able to justify military man in space because he adds a dimension of effectiveness that we cannot logically achieve without him.

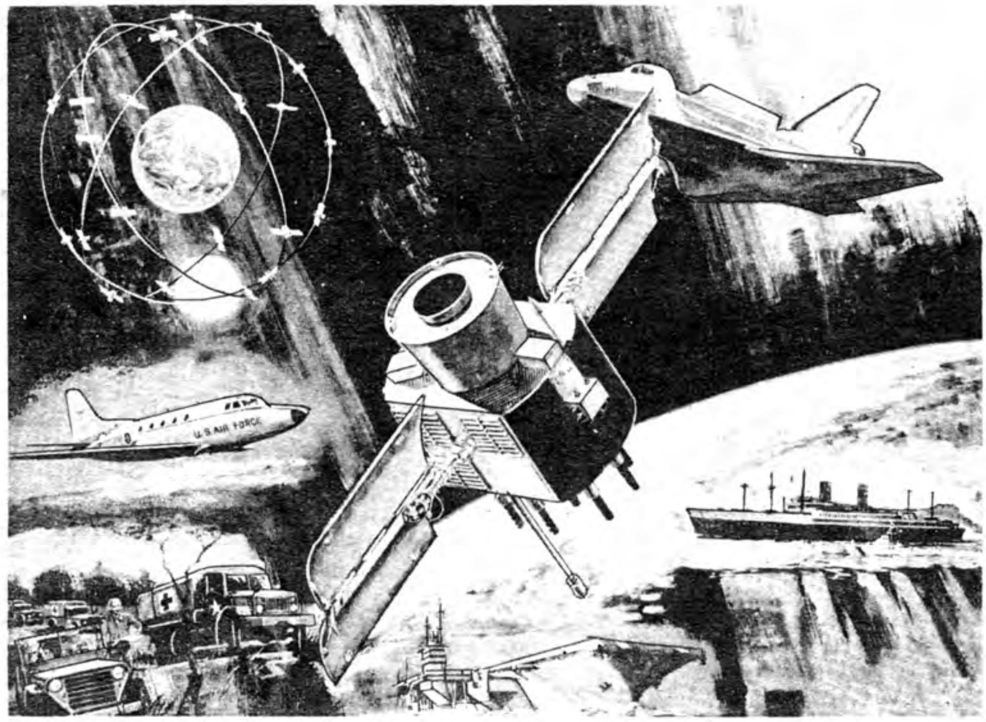
"As we plan for the future, it becomes very clear that the U.S. must be able to defend and protect its space assets. To meet this objective, we are developing an anti-satellite capability. The Soviets already have one.

"The alternative to not having this capability or the ability to respond to an enemy attack on our space systems would limit our political or military choices. We could respond by doing nothing, by attempting a political solution, or by taking some type of military action.

"All of these alternatives may be unacceptable for a particular situation. I believe that we will continue the development of a good and effective anti-satellite capability," the General said. "I believe further that the development effort will be highly successful.

"The attainment of survivable space systems is a complex, multifaceted challenge. It is not sufficient to provide survivability just to the satellites in space. We must also be able to protect the command and control ground links as well as the launch facilities. We must be able to identify and detect any overt or covert interference with our satellite systems.

"The mode of attack options open to any aggressor could could range from actual overt interference with our space or ground systems or the covert use of electronic measures or lasers. We are actively working on a number of sensors that will detect outside interference that could adversely impact our free use of space. We are also actively working on new computers—fault tolerant long life computers—for



SPACE SERVICES. The NAVSTAR global positioning system (GPS), being developed by the Department of Defense and managed by the U.S. Air Force's Space and Missile Systems Organisation, will become operational in the mid-1980's. NAVSTAR satellites will blanket the Earth with continuous navigation signals, and user receivers on Earth, in the air, or in space can instantaneously process those signals into exact three-dimensional navigational positions and velocities. NAVSTAR satellites, developed and built by Rockwell International's Satellite Systems Division, are in orbit and operating successfully.

Rockwell International

use on our new spacecraft.

"Computers are just as ubiquitous in the space business as they are in the aircraft business if not more so. We have had to put very special care into the design of spaceborne computer hardware to ensure fault-free, long-term orbital performance. This generally means that space computer hardware is exceedingly expensive.

"There is a corollary high expense for software in space systems. In general, I think it's safe to say that spaceborne computer programmes are larger and more complex than similar programmes providing similar functions for ground or aircraft applications. This is because of the extra "margin of safety" or programme reliability required through fault tolerant programmes.

"And, of course, since most satellite—and even shuttle—payloads are basically electronic and radiate or receive in the electromagnetic spectrum, they have the normal vulnerabilities of any electromagnetic system.

"In this day and age, compensating for those vulnerabilities involves high speed digital computer techniques, such as those employed in programmable signal processors or adaptive antennae arrays."

Ground-based Systems

"There is another side to the coin. The ground based systems which monitor, control, and support those spacecraft. They are also complex and expensive.

"The commander of AFSC's Space and Missile Systems Organisation (SAMSO), Lieutenant General Dick Henry, likes to use the analogy of his "ten thousand mile screwdriver" to represent the idea that he still has to control and maintain his space systems once they're launched. He uses those same data streams I mentioned earlier to ship data up to the space vehicles to turn them on or off; to correct their orbital position; perhaps to exercise faulty diagnostic systems; or even to reprogramme satellite computers.

"Obviously, very sophisticated software is needed in space vehicle computer programmes to provide complex interfaces to that 10,000 mile long screwdriver with all of its associated data streams.

"To accompany the larger and more complex spaceborne computer complexes and associated software is the growing complexity of the ground control facilities at the "handle" end of the 10,000 mile screwdriver—such as at our satellite control facilities. These major facilities combine large general purpose 'data crunching' mainframe computers, usually interconnected with software controlled display systems.

"The programmes associated with these ground facilities usually exceed in size the spaceborne programmes by several orders of magnitude, with all of the attendant complexities of programme development and support. In avionics and C^3, the main operational programme will be backed up by massive support programmes which constitute that invisible part of the software iceberg just below the surface. Spaceborne computers must have similar and even more complex backup.

"So what I'm saying is that it's not simply a matter of just identifying the right applications for space—or capturing the obvious benefits. It's a matter of evaluating and trading off those benefits against the very real costs and burdens it will place on our scarce resources, like software programmers, system designers and budget dollars.

"I believe that we in the Air Force understand and appreciate as well as most the current value and the high potential of space applications as related to our military missions.

"We are certainly already a quantum jump past the concepts of "getting higher to see farther" and our understanding and appreciation grows every day. Hopefully, our more sophisticated understanding of why and how we want to use this new domain will be accompanied by application of the many 'lessons learned' from the aeronautical experiences of our operators, technologists, and support people.

"In any event, we have not, and will not rush into space in search of some ill-defined military mecca. Thus far, I believe our space ventures have been well reasoned and pragmatic," General Slay concluded. "We have only ventured into space when the potential pay-off in terms of capability and mission effectiveness was clear and compelling. That will remain our policy."

SCIENTIFIC INSTRUMENTS ON MILITARY SATELLITES

By Joel Powell

Introduction

Since the first American military satellites, the Discoverers, scientists have had the opportunity to fly scientific experiments as piggy-back additions on classified satellites. With very few exceptions these experiments have been virtually unknown to the public. Many experiments took advantage of the polar orbits of most military satellites which were not generally available to the civilian NASA until the mid-1960's. Instruments were provided to map zones of precipitating radiation at low altitudes and to chart artificial radiation belts created by high altitude nuclear tests (Project "Fishbowl"). Auroral radiation was probed as was the ionosphere and the upper atmosphere. SECOR (Sequential Collation of Range) beacons and flashing lights were used in the first space-borne geodetic research. The instruments themselves were usually mounted on the rear engine section of the Agena stage (*Scientific Satellites,* Corliss, NASA,SP-133, p. 790).

Table 1. Scientific Instruments known on Military Satellites

Launch Date	Designation	Mission	Instruments	Reference
April 9, 1962	1962 K1	Midas 5[1].	proton detectors, 6 Westford needles (34cm. long) 2	2.
April 17, 1962	1962 A1	recon[1].	ion trap, neutron albedo measurement	3.
April 28, 1962	1962 P1	recon[1].	neutron albedo measurement	4.
May 15, 1962	1962 Σ1	recon[1].	emulsion, dosimetry film in return capsule	5., 6.
May 30, 1962	1962 Φ1	recon[1].	emulsion, dosimetry film	5., 6.
June 27, 1962	1962 AΓ1	recon[1].	emulsion, dosimetry film	5., 6.
July 21, 1962	1962 AH1	recon[1].	neutron albedo measurements, radiometer/spectrometer	4.
July 28, 1962	1962 AΘ1	recon[1].	emulsion, dosimetry film	5., 6.
Aug. 2, 1962	1962 AK1	recon[1].	emulsion, dosimetry film.	5., 6.
Aug. 29, 1962	1962 AE1	recon[1].	emulsion, dosimetry film	5., 6
Sept. 1, 1962	1962 AT1	recon[1].	proton, electron detectors	7
Sept. 17, 1962	1962 AX1	recon[1].	emulsion, dosimetry film, neutron albedo meas., radiometer	5., 8., 9.
Oct. 9, 1962	1962 BE1	recon[1].	emulsion, dosimetry film	5., 6.
Oct. 26, 1962	1962 BK1	ferret[10].	'Starad'. Impedance probe, spectrometers, proton detectors	11.
Nov. 5, 1962	1962 BO1	recon[1].	emulsion, dosimetry film	5., 6.
Dec. 14, 1962	1962 Bϕ1	recon[1].	emulsion, dosimetry film	5., 6.
April 1, 1963	1963 7A	recon[1].	emulsion, dosimetry film	5., 6.
May 19, 1963	1963 16A	recon[1].	auroral electron detectors	12.
Aug. 29, 1963	1963 35A	recon[1].	emulsion	13.
Oct. 29, 1963	1963 42A	recon[1].	electron detector, ion trap, proton detector	14.
June 13, 1964	1964 30A	ferret[15].	'Starflash'. Flashing light for geodetic purposes	16.
Aug. 21, 1964	1964 48A	ferret[15].	'Starflash'. Flashing light for geodetic purposes	16.
Nov. 18, 1964	1964 75A	recon[1].	'ORBIS' Orbiting Radio Beacon Ionospheric Satellite.	17.
Feb. 25, 1965	1965 13A	recon[1].	auroral electro detectors, radiometer	18.
Nov. 9, 1965	1965 90A	recon[1].	ion, proton, electron detectors	19., 20.
May 22, 1967	1967 50A	recon[1].	'LOGACS' Low G Accelerometer Calibration System; atm. density study	21.
Aug. 7, 1967	1967 76A	recon[1].	cosmic X-ray spectrometer	22.
June 25, 1970	1970 48A	recon[1].	air density study with MESA Mini Electrostatic Accelerometer	23.
Aug. 18, 1970	1970 61A	recon[1].	air density study with MESA Mini Electrostatic Accelerometer	23.
Nov. 6, 1970	1970 93A	early warning[27].	solar proton detectors	24.
Mar. 27, 1972	1972 10A	early warning[27].	solar proton detectors	24.
April 19, 1972	1972 32A	recon[1].	S71-3 payload, instruments unspecified	25.
April 10, 1974	1974 20A	recon[26].	S73-7 payload, instruments unspecified	25.

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Table 2. Appendix. Discoverer & others Instruments

Launch Date	Designation name	Instruments	Reference
Sept. 13, 1960	Discoverer 15	flashing lights for geodetic purposes	1.
Nov. 12, 1960	Discoverer 17	emulsion in recovery capsule	2.
Dec. 7, 1960	Discoverer 18	emulsion, biological and human tissue samples	3., 4.
Feb. 17, 1961	Discoverer 20	materials samples, flashing lights, radiation detectors	5.
Apr. 8, 1961	Discoverer 23	flashing lights for geodetic purposes	6.
July 7, 1961	Discoverer 26	ion detectors, alloy samples, micrometeorite detector	7.
Aug. 30, 1961	Discoverer 29	emulsions, electron spectrum detector, biological samples	8.
Sept. 12, 1961	Discoverer 30	radiation sensors, biological samples	9.
Sept. 17, 1961	Discoverer 31	X-ray counter, galactic RF detector, proton and electron detector	10,11.
Oct. 13, 1961	Discoverer 32	ion trap, electron micrometeorite detectors, material samples	12.
Nov. 5, 1961	Discoverer 34	electron detector, antenna impedance measurement	13.
Nov. 15, 1961	Discoverer 35	electron detector, biological sample, alloys, radio scintillation	14.
Dec. 12, 1961	Discoverer 36	impedance meas., emulsions, proton, cosmic ray detectors, biological alloys	15.
Feb. 27, 1962	Discoverer 38	radio scintillation, magnetometer, alloys, electron detectors	16.
Jan. 31, 1961	Samos 2	Atmospheric density (ram-air sensor)	17.
May 24, 1960	Midas 2	magnetometer, micrometeorite detector, ions and electrons	18., 19.
July 12, 1961	Midas 3	proton detector	20.
Oct. 21, 1961	Midas 4	proton detector	20.
Nov. 15, 1961	Traac	geiger counter	21.

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Discoverer Programme

This work was started on the Discoverer project from 1959-62. From two to five radiation detectors were carried on nearly every satellite. Magnetometers were also carried. (*Above & Beyond Encyclopaedia*, 4, p. 639). Important studies of the effect of the space environment on alloys and materials were carried out as were biological experiments to learn the effect of the space environment.on living organisms. Human tissue and bacteria were used. The first biological experiment carried on Discoverer was four mice housed in the return capsule of Discoverer 3, but it failed to orbit (*Encyclopaedia of Space*, McGraw-Hill, 1968, p. 196).

To better study radiation particles emulsions and dosimetry films were often carried on the return capsules of Discoverer and classified satellites (NASA SP-133, p. 512). The packages were usually water-tight steel and aluminium cassettes mounted on the rear ballast plates of the capsules.

The energy, direction and perhaps source of the particles could be determined from these passive emulsion stacks.

Other instruments studied upper atmospheric density, galactic X-ray emission, radio scintillation and very-low frequency radio signals and ionospheric structure using impedance probes (NASA SP-133, p. 447). The Earth's radiance was studied by infrared interference spectrometers (NASA SP-133, p. 446). Spectrometers and radiometers also studied the atmosphere's ozone content.

One of the more interesting (and well-known) experiments conducted was the 'Westford' project for communication tests with tiny orbiting needles. The needles were dispensed from the Midas 6 satellite in an ejectable cannister using sublimating napthelene. The needles spread out in a belt around the Earth but did not show enough promise for further investigation. Midas 4 also carried the needles but the effort failed (*Science and Mechanics*, September 1963, p. 36). For a further test see chart.

Space Test Program

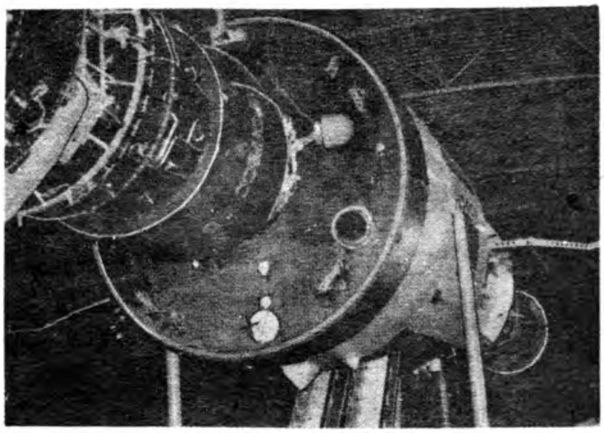
The practice continues today in the Space Test Program. 'Secondary payloads' are carried on reconnaissance satellites and also early-warning satellites and Block 5D weather satellites—auroral studies in this case. *(Astronautics & Aeronautics*, AIAA, June 1974, p. 44). Incidently, the Soviets have maintained a similar effort on military satellites from Cosmos 4 to the present. This effort using add-on instruments and jettisonable modules is well documented in The Library of Congress report on Soviet space programs, 1975.

THE PROSPECT OF SOVIET ORBITAL CONSTRUCTION IN THE SUMMER OF 1977

By Nicholas L. Johnson

Introduction

Since 1976 the Soviet Union has undertaken what appears to be an extensive research and development project for the next generation of manned orbital activities. *Spaceflight* readers are acutely aware of the yet to be resolved performances of the Proton launched Kosmos 881/882, 929, 997/998, and more recently 1100/1101. The three dual missions have been widely associated with the Soviet space shuttle programme, while Kosmos 929 exhibited the capabilities to act as a space tug [1]. The purpose of this paper is to examine a possible mission profile aimed at the first in-orbit construction of a manned space station.



Rear view of Salyut 6 space station with unmanned Progress cargo ferry docked. Exhibit at the Paris Air Show, Le Bourget, 1979.

Theo Pirard

Summer of '77

During the spring and summer of 1977 several indicators had pointed to a resurgence of Soviet manned space activity in the late summer or early fall of that year. The military space station Salyut 5 had obviously completed its mission in the beginning of the year, and the world awaited the expected launch of a new civilian Salyut. Soviet officials had already proclaimed to the rest of the world that a new dual-ported Salyut was imminent and that these new orbital laboratories would also be equipped for in-space refuelling from automated tankers [2]. In addition, 4 October 1977 marked the 20th anniversary of the launch of Sputnik 1, strongly suggesting a space spectacular worthy of such a momentous occasion.

On 17 July 1977 Kosmos 929 was launched into a 275km by 227km orbit at an inclination of 51.6°. Over the following two hundred days this spacecraft performed about a dozen manoeuvres for a total dV of just under 300 m/s. This represents a significant fuel capacity for such a large spacecraft. The mystery of Kosmos 929 is not *how* it carried out its manoeuvres, but *why?* Other than demonstrating a reliable restart capability, coupled with both slight and major orbital changes, the flight of Kosmos 929 seems to lack that final piece of the puzzle which would make the picture complete.

Ten weeks after the launch of Kosmos 929, Salyut 6 was orbited and began the extremely successful two year programme which it has completed to date. Although Kosmos 929 was in an orbit only slightly lower than Salyut 6, there was no apparent connection between the two spaceships.

However, a recent report in *Soviet Aerospace* provides information which may indeed link these two space vehicles to a more ambitious project [3]. The report summarises the progress of the assumed Soviet space shuttle effort by reviewing the flights of Kosmos 881/882, 997/998, and 1100/1101. In addition, mention is made of an apparent Proton-class launch failure on 4 August 1977. The article attributes this flight attempt to the second of the shuttle proving tests which subsequently had to be carried out by Kosmos 997/998.

The question to be raised here is whether this launch failure, if true, can be attributed to the Soviet space shuttle effort or to the Soviet space station programme. While the first alternative is certainly viable, evidence will now be presented which makes a reasonable case for the latter possibility as well.

Following its launch on 17 July 1977 Kosmos 929 did not perform detectable orbital manoeuvres for ten days. This could be associated with the time needed to ready the next Proton launcher, since the second Proton launching pad was occupied by the waiting Raduga 3 which was launched on 23 July. Then three minor orbital changes were

made at three day intervals: 27 July, 30 July and 2 August. It appeared that the spacecraft was being positioned in conjunction with a future mission, but for the next two weeks no further changes were noticed. Between 16 and 18 August the character of Kosmos 929 abruptly changed. An orbital manoeuvre on 17 August raised and circularised the rapidly decaying orbit, followed the next day with a further raising to 360 km by 306 km. Detailed analysis of Kosmos 929's telemetry transmissions by the Kettering Group indicate that a change in transmission format also occurred during this time period [4]. Not only did the mode A synchronisation train change from 30 pulses to 29 pulses, but also the Soyuz-type 166.0 MHz signal heard earlier in flight ceased.

What happened between 2 and 17 August to warrant such a change? I believe that a plausible explanation rests with the reported 4 August launch failure of a Proton payload. Although orbital manoeuvring is essential for a space tug, equally important is its ability to rendezvous, to dock, and to successfully relocate its fare. A test which did not include these latter objectives would be only partially complete. The possibility remains, therefore, that the 4 August flight was designed to orbit a payload which was then to be transferred by Kosmos 929–perhaps to the upcoming Salyut 6 space station.

Modular Assembly?

Let us now examine the possible nature of such a payload. Two types of spacecraft readily come to mind: a Salyut space station to be joined head to head with the later launched Salyut or a specialised work module to be attached to Salyut 6.

The first option is certainly not new to followers of the Salyut programme. Soviet officials have for years talked of joining two, three, or more Salyuts together to form more elaborate and versatile space platforms. An illustration of two such coupled Salyuts can be found in *Spaceview* [5]. The question arises, however, is a space tug required for the construction of such a complex? I think not. The Soyuz/Salyut rendezvous procedures should work equally well in an unaided Salyut/Salyut situation.

Furthermore, the docking of a space tug to a Salyut station and then transferring to a second Salyut can be shown to be less economical from a fuel standpoint as well as the added cost and complexity of the tug itself. Kosmos 929 was inserted into a standard initial orbit used by Salyuts 2-6: 275 km by 227 km. From this orbit the most likely manner to rendezvous with an intended target would be to place the target into a circular 225 km orbit on launch. Then a Soyuz 10/Salyut 1 type manoeuvre could be employed, lowering Kosmos 929 into the lower circular orbit. This action would consume close to 100 kg. of propellants (75 kg. to lower and circularise Kosmos 929's orbit and another 25 kg. for rendezvous maneouvres). Then the docked pair would need another 900 kg. for the burns to achieve a circular 350 km. orbit which is the operational orbit of civilian Salyuts. (Assume the space tug mass is 16,000 kg, Salyut mass is 19,000 kg, and the specific impulse of the propulsion engine is 282 sec.) Thus a total expenditure of 1,000 kg. of propellants would be expected. In contrast, only about 350 kg. of propellants is needed for a Salyut to push itself from its usual initial orbit of 275 km. by 225 km. to a 350 km. circular orbit.

Thus, if Kosmos 929 was to be used to bring some payload to Salyut 6, that payload probably was not a second Salyut, but some other spacecraft which did not contain its own propulsion system. This latter aspect is important since several thousands of kilograms are "wasted" on the installation of engines, propellants, and an attitude control system. Here, use of a space tug would permit virtually the entire 19,000 kg. payload of a Proton booster to be devoted to the utilitarian construction of a space station module. Recently, Soviet officials have been speaking more and more emphatically that such modules will soon appear [6].

The previous calculations would require an expenditure of about 1,000 kg. of propellants to join such a payload to an orbiting Salyut. The manoeuvres carried out by Kosmos 929 indicate that the craft held in excess of 1,600 kg. of propellants.

Although the design of such a proposed space station module is impossible to predict, at least two docking ports (one probe type, one drogue type) are needed. The probe type docking unit is needed for mating with the drogue port at Salyut's front end. The other end of the module should have one (or more) drogue ports for mating with the space tug and subsequent manned Soyuz vehicles.

Conclusions

In summary, it is suggested that Kosmos 929 was a space tug whose mission was to couple Salyut 6 with a specialised work module. Unfortunately, the module was lost during launch and Kosmos 929 was left without a mission other than evaluation of its propulsion system. Salyut 6 which probably was scheduled for a late August launch was then postponed until late September to permit a new mission profile to be written.

The above scenario is by no means purported to be the actual chain of events. It merely presents a possible explanation for the yet to be resolved happenings and unfulfilled expectations of the summer of 1977. Surely, the demonstration of a dual-ported Salyut, a space tug, orbital construction of an enlarged space platform, and automatic refueling and cargo ships would have been a fitting tribute to the 20th anniversary of the space age.

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A LONG-TERM SPACE POLICY FOR EUROPE

Continued from page 494]

systems, it was considered premature to formulate specific recommendations, except to propose that they be studied carefully. Account of them should be taken in defining the future developments of ARIANE, and Europe should be ready to adopt, for instance, the concept of an automatic space laboratory when the time for decision arrives, probably around 1985, when Spacelab experiments will have provided more information on what processing can be performed efficiently in space.

All these development activities require a total of 4400 MAU for the eleven-year 1980 to 1990 period, with maxima of 530 MAU per year in 1985, '86 and '87, when the activities will be at their highest level.

THE MYSTERY OF LUNA 10 AND LUNA 11

Introduction

In 1976 a Soviet book appeared which gave details of various rocket engines which have seen an application in their space programme. One of the engines considered was that used on the second generation of the 'Luna' probes, numbered 4 to 14 (together with various failures either unnamed or given the 'Cosmos' identity which failed to leave Earth parking orbit), and the data presented has allowed various calculations to be made about the Luna probes. In general, the figures seem to square with other Soviet data announced at the times of the flights (1963-1968), but the data for Lunas 10 and 11, the first lunar orbiters flown by the Soviet Union, does not fit with the rocket data. It is therefore the intention of this article to present the problem, in the hope that someone can come up with a solution which agrees with *all* the announced Soviet data.

The Engine System

Data for the second generation Luna engine system appeared in the Soviet publication *Kosmicheskiye zhidkostno-raketnyye dvigateli* (Liquid Rocket Space Engines) by V. N. Bychkov, G. A. Nazarov and V. I. Prishchepa, which has subsequently appeared as a NASA translation. The Luna engine is designated KDTU-1, and has a thrust of 4,640 kgf with a specific impulse of 2,720 m/s, or 277 sec [1]. The system included a single-chamber liquid rocket engine with a pump feed of the same fuel as used on the 'Vostok' TDU-1 retro-fire engine.

Before presenting the 'mystery' data for Lunas 10 and 11, data will be given for other flights of the second generation series for which reasonable results can be obtained.

Lunas 9, 12, 13 and 14

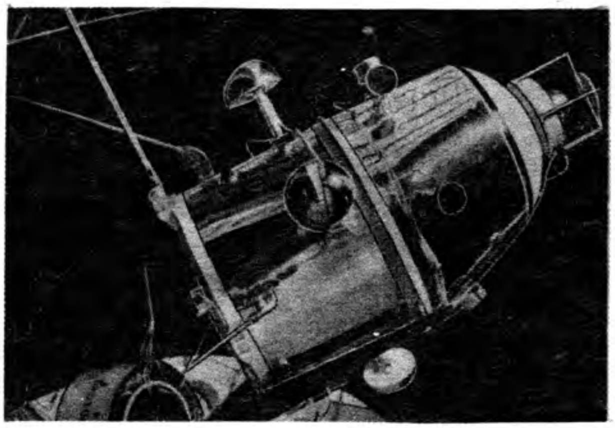
Table 1 is a summary mass breakdown for the above Luna probes. In calculating the fuel required for each mission, a mid-course correction capacity of 100 m/s has been assumed: it is known that Luna 9 completed a MCC of 71.2 m/s [5], although it should not be assumed that this is the upper limit for the probe.

Table 1. Data for Lunas 9, 12, 13 and 14

Mission	Luna 9	Luna 12	Luna 13	Luna 14
Final dV, m/s	2600	937	2600	911
Payload, kg	*100*	466	*109*	475
Propulsion module, kg	370	370	370	370
Strap-ons, kg	300*	300**	300*	300
Fuel, kg	813	529	826	515
Total Mass, kg	*1583*	1665	1605	1660

The delta-Vs to reach lunar orbit are found from [2] and [3] for Lunas 12 and 14 respectively. Data in *italics* is that announced by the Soviet Union. *Separated before retro-fire. **Total mass after lunar orbit injection was 1136 kg [4].

Luna 9 was the first spacecraft to "soft land" on the Moon in early February 1966, and Luna 13 was a second "soft-lander" in December of the same year. They seem to be akin to the American Ranger 3-5 vehicles in that they made "hard" rather than actual "soft" landings on the Moon. Lunas 4 to 8 were all lunar landing attempts which failed, and apart from their total masses, we have no further mass breakdowns for the probes.



LUNA 10 automatic station on display in the Cosmos Pavilion of the USSR Exhibition of Economic Achievement, Moscow.

Novosti Press Agency

The Soviets have announced the initial masses of the Luna probes up to Luna 11, and the mass of the lander for Luna 9 is also known. From the delta-V requirements and the now-known engine characteristics, it is a simple matter to calculate that the mass of the retro-fire module when empty is about 370 kg, as shown in Table 1. Since the Luna 13 capsule was 109 kg, it is possible to calculate backwards to obtain a launch mass of about 1605 kg.

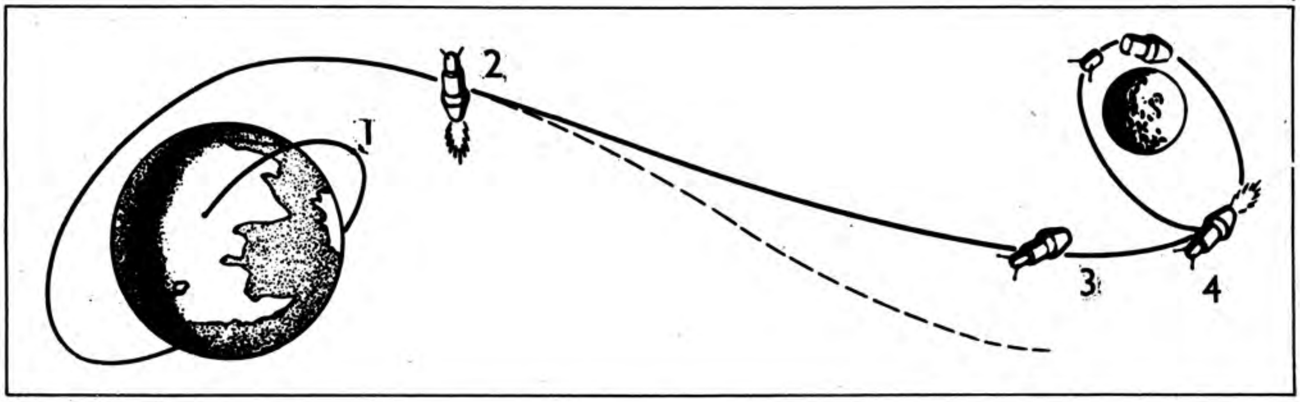
Luna 12 was a single-module lunar orbiter, with the scientific apparatus wrapped around the retro-fire module: however, for simplicity I have shown the science package as the "payload" in Table 1. The mass of Luna 12 in lunar orbit has been announced as 1136 kg, so once more we can work back to obtain an estimate of the initial spacecraft mass. There has been some debate as to whether Luna 14 was similar to Luna 12 or a throw-back to the Luna 10 spacecraft. However, the answer can be found in the Soviet book *Pokoryenye Kosmosa* [6]. Both the 1969 and 1972 editions show Zonds 5 and 6 to be simply Soyuz craft without an orbital module in a fold-out spread depicting Luna probes and Zond/lunar missions, so this would seem to suggest that the drawing is accurate, especially since the "first" picture of a Zond was not supposedly released as a drawing until after the programme's completion.

However, to return to the Luna probes. Luna 14 is shown to be identical to Luna 12, other than the former did not apparently photograph the Moon (although it might have been intended to). It is possible that Luna 14 was flown as an after-thought to obtain lunar orbit data before the manned Zond missions were to begin in late 1968 (the manned flights did not come as planned). In Table 1, therefore, I have simply rounded the payload mass for Luna 14 to the nearest 25 kg from that for Luna 12.

All in all, the figures shown in Table 1 do not show any real problems, but these arise with the two missions which give this article its title.

Lunas 10 and 11

The Soviet book *Pokoryenya Kosmosa*, already mentioned, shows that Luna 11 was the same type of probe as Luna 10, other than the lunar satellite remained attached to the Luna 11 retro-fire module. Mass breakdowns for these two



Luna 10 was set-on course for the Moon by the Soviet Union on 3 April 1966 to become the world's first lunar artificial satellite. 1. Earth parking orbit; 2. mid-course correction. 3. Orientation of Luna 10 before retro-fire. 4. Retro-fire and entry into lunar orbit.

Novosti Press Agency

missions are shown in Table 2, although only Luna 10 will be considered in detail. The same comments will apply to Luna 11, but to consider both missions in the same detail would not add anything to the problem which arises.

The launch mass for Luna 10 was announced as 1,600 kg, the same order of magnitude as the Luna lander series, and the mass of the small satellite which separated from the retro-fire module after lunar orbit injection was 245 kg. Since the same retro-fire module was used on these orbiters as on the Luna 9 lander previously considered, the same mass has been assumed. Certainly, the masses will not have differed to a great extent. After the usual calculations of a MCC of 100 m/s and the LOI burn, we are left with a mass in lunar orbit for Luna 10 of 910 kg, while it should only be 615 kg: this difference of 295 kg is shown as "Other" in Table 2 which follows. The payload for Luna 11 seems to be virtually the same for Luna 10, but calculations show that the initial mass implies an increase of some 220 kg, which although not impossible seems improbable. It will be noted that Luna 11 retained its strap-on equipment after lunar orbit injection, while that for Luna 10 was cast off before the manoeuvre.

Table 2. Data for Lunas 10 and 11

Mission	Luna 10	Luna 11	Luna 10(2)	Luna 10(3)
Final dV, m/s	850	900	850	850
Payload, kg	*245*	465	*245*	*245*
Other, kg	295	-	400	-
Propulsion module, kg	370	370	370	370
Strap-ons, kg	300*	300	300*	300*
Fuel, kg	390	505	285	270
Total Mass, kg	*1600*	*1640*	*1600*	1185

The delta-Vs to reach lunar orbit are found from [7] and [8] for Lunas 10 and 11 respectively. Data in *italics* is that announced by the Soviet Union. *Separated before retro-fire.

Two other mass calculations are given for Luna 10 in Table 2. The one shown as Luna 10(2) assumes that the "other" payload was somehow "lost" between MCC and LOI, while the Luna 10(3) figures assume that there is no missing payload. In the latter case, the initial mass of Luna 10 comes to be less than ¾ of the announced figure.

Therefore, it can clearly be seen that the launch mass of Luna 10 and the lunar satellite mass do not tie in with the announced characteristics of the KDTU-1 retro-engine system.

Conclusions

There is a serious discrepency in the announced data for Luna 10, and the hint of a possible similar situation with Luna 11. This can be accounted for in one of four ways.

(1) Some mass was injected into lunar orbit, but was not accounted for (see also (3)).

(2) Some equipment, other than the strap-on apparatus, was cast off Luna 10 before entry into lunar orbit.

(3) There is no mass discrepency, and only part of the fuel carried on Luna 10 was used for lunar orbit injection (therefore, the retro-fire module still carried nearly 300 kg of fuel).

(4) The Soviet Union announced the correct data for lunar orbit, but the launch mass of the complete probe was over-stated so that unfavourable comparisons would not be drawn with the masses of the earlier Luna flights.

Suggestions (1) and (2) seem untenable, while if suggestion (3) were to be correct, one wonders why the unwanted 300 kg of fuel was carried instead of experiments. Although one does not like to suggest that the Soviets have announced false data, in the writer's opinion suggestion (4) seems the most probable.

REFERENCES

1. V. N. Bychkov, G. A. Nazarov and V. I. Prishcepa, *Liquid Rocket Space Engines*, NASA Technical Translation F-17503, p. 28.
2. *Pravda*, 6 November 1966.
3. *Pravda*, 12 April 1968.
4. G. S. Narimanov *et al.*, *Pokoryenye Kosmosa*, Mashinostroyeniye Press (1969 and 1972), p. 75.
5. *Pravda*, 6 February 1966.
6. G. S. Narimanov *et al*, *ibid*, between pp. 76-77.
7. *Pravda*, 5 April 1966.
8. *Transmission from Luna 11*, Translation FTD-HT-23-1513-67, Foreign Technology Division, WP-AFB, Ohio, 14 May 1968.

SATELLITE DIGEST - 132

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed description of the information presented can be found in the January, 1979 issue, p. 41.

Continued from November issue]

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Cosmos 1117 1979-68A 11463	1979 Jul 25.63 13 days (R) 1979 Aug 7	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	179	324	62.80	89.53	Plesetsk A-2 USSR/USSR
Cosmos 1118 1979-69A	1979 Jul 27.31 13 days (R) 1979 Aug 9	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	211	246	81.36	89.09	Plesetsk A-2 USSR/USSR
Molniya-1(44) 1979-70A	1979 Jul 31.16 12 years?	Cylinder-cone + 6 panels + 2 antennae 1000?	4.2 long 1.6 dia	452	39902	62.84	717.73	Plesetsk A-2-e USSR/USSR
Cosmos 1119 1979-71A	1979 Aug 3.45 12 days (R) 1979 Aug 15	Sphere + cylinder-cone? 5500?	5 long? 2.4 dia?	214	240	81.35	89.10	Plesetsk A-2 USSR/USSR

Amendments:
1979-49A, Soyuz 34 was recovered 1979 Aug 19.521 (1230 UT) after 73.763 days (73 days, 18 hours. 18 min.). Lykakhov and Ryumin were in flight for 175.025 days (175 days, 36 min.).

THE RELUCTANT SHUTTLE

By Gordon L. Harris

Introduction

Under sharp fire from the U.S. Senate for inadequate management of the Shuttle programme, NASA has turned away from basic concepts in an obvious effort to put "Columbia," its first orbiter into space.

Already, at least a year behind schedule, which has sharply increased programme costs, "Columbia" was transferred from a California manufacturing plant to Kennedy Space Center before completion. The reason for this move in March, 1979 remains somewhat obscure.

Astronaut Robert Overmyer, assigned as deputy orbiter manager by Johnson Space Center, says the availability of "Columbia" at the launch base permitted pre-flight testing with launch related systems. Currently astronauts are checking performance of primary and backup flight control systems while Rockwell International continues to apply thermal protection tiles to the spacecraft's outer skin.

Both Kenneth Kleinknecht, brought back from NASA's Paris Office to speed up "Columbia", and Overmyer as his deputy, have made it clear that some things are being done on a one-time only basis in hope the Shuttle can be launched for the first time in mid-1980.

Revised Schedule

Three hydrogen-oxygen engines have been installed in "Columbia" at the Florida base. They are not flight ready, however, since a recent fire during static test of a similar engine in Mississippi made a valve redesign necessary.

Overmyer is confident that valves can be changed without delaying launch preparations but admitted a new valve can-not undergo static test until October. Should it fail, "Columbia" must await more design changes. If it succeeds the spacecraft will leave the manufacturing facility on 24 November to enter the giant Vehicle Assembly Building where two solid rocket boosters and an external fuel tank will be mated to the orbiter.

NASA Administrator Robert Frosch, who has an in-house committee reviewing shuttle management, gives "Columbia" a 50-50 chance of launch next June. Meanwhile the agency is studying the advisability of a short-duration, sub-orbital mission on the first flight.

The fact that such an investigation is underway hints of dwindling confidence in the reusable space machine. It recalls the 1961 situation when NASA flew Alan Shepard and Virgil Grissom on sub-orbital missions because it then lacked a qualified booster capable of orbital transfer.

Installing Thermal Tiles

While Congress worries about rapidly increasing costs (the Shuttle was approved as a $5,200 million development in 1972 but has already reached the $7,000 million level), 350 Rockwell employees toil over the heat protection materials.

Four types of materials are required:

1. Coated Nomex felt reusable surface insulation applied in areas where temperatures are less than 371 degrees Celsius during reentry and 398 degrees Celsius during ascent: upper payload bay doors, mid-and-aft-fuselage sides, upper wing and pods housing the orbital manoeuvring and reaction control systems.

2. Low temperature insulation in areas where temperatures are below 648 degrees Celsius and above 371 degrees: lower payload bay doors, forward, mid-and-aft-fuselage, upper wing and vertical tail.

3. High temperature insulation in areas where temperatures are below 1260 degrees Celsius and above 648 degrees: forward fuselage, lower mid-fuselage, lower wing, portions of the vertical tail and forward fuselage window areas.

4. Reinforced carbon-carbon where temperatures exceed 1260 degrees Celsius: wing leading edge and nose cap.

NASA observed that "the protection system has been designed for ease of maintenance and for flexibility of ground and flight operations while satisfying the primary function of maintaining acceptable airframe outer skin temperatures."

At a recent press briefing, Overmyer introduced a short film depicting the procedures developed by Rockwell to install high temperature tiles. "Columbia" requires 31,000 tiles in all, 10,000 of which were missing when the vehicle arrived in Florida.

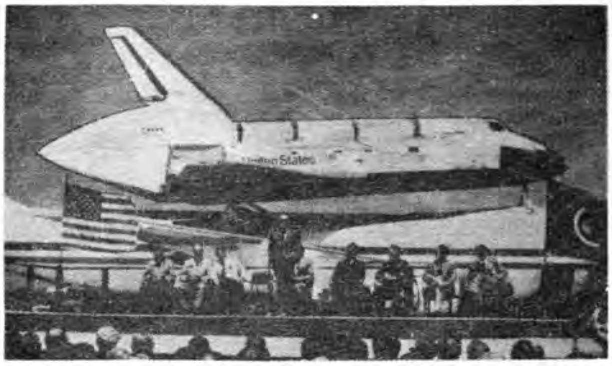
It would be difficult for a layman to conceive a more tedious, time-consuming and costly process than the film disclosed. Each tile must be individually designed, manufactured and installed and while it supposedly will withstand 100 missions, a Kennedy Space Center engineer estimated as many as 2,000 tiles may need replacement after the first launch.

A mould is made of each "cavity" by using a Plaster of Paris type compound. The mould is shipped to Rockwell at Palmdale, California, by air freight for manufacture of the tile. Quoting NASA's latest fact sheet: "The tile measures 15.24 by 15. 24 cm. It is made of a low density high purity silica (glass), 99.7 per cent amorphous fibre (derived from sand one to two mills thick) made rigid by ceramic (clay) bonding. Ninety per cent of the tile is void, 10 per cent is material which results in a weight of 4 kilograms per cubic metre, with the exception of tiles applied around the nose and main landing gear doors, external tank umbilical doors, vent doors and vertical stabilizer attachment which requires 9.9 kilograms per cubic metre density. A slurry containing fibres mixed with water is frame cast to form soft, porous blocks to which colloidal silica binder solution is added. When dried, a rigid block is produced, cut into quarters and then machined to the precise dimensions required for a single tile."

Tiles vary in thickness from 2.54 to 12 cm. They are coated on top and sides with a glass mixture formed by mixing tetra silicide with boro-silicate glass in a powder with a liquid carrier to a thickness of 16-18 mills. Baked to 1260 degrees Celsius they emerge with a black waterproof exterior with surface emittance of .85 and a solar absorption of .85.

Each tile is carefully wrapped – gloves must be worn by operators handling the item at all times – boxed and air-lifted to the launch base. Since the high temperature tile cannot withstand airframe contraction and expansion, a strain isolation pad is now applied. This is the same Nomex felt material utilized in areas where heating is less severe.

After the pad is bonded to the tile, an installer takes over, consulting a large master chart keyed to numbers identifying separate tiles to ensure correct placement. He brushes cement on the "cavity", taking mechanical readings of its thickness, then places the isolator pad and tile. Now a specially designed mechanical device is brought into play exerting pressure on the outer side of the tile for a minimum of 16 hours.



COLUMBIA' AT THE CAPE. First orbital flight vehicle shortly after arriving at the Kennedy Space Center on 24 March 1979 with much assembly work remaining to be done on site. NASA Administrator Dr. Robert A. Frosch addresses KSC employees and their families.

After a slow start extending over four months, the tile placement rate had reached an average of 1.85 per man week by mid-August. Astronaut Overmyer confidently forecast a 600 tiles per week rate thereafter which would finally complete the process in time for November rollout.

Overmyer explained that NASA chose the tile method in 1972 because weight constraints ruled out an ablation material, like that employed on Apollo spacecraft, or a heavier metal in the Orbiter skin.

He quickly added that the agency is looking into better methods of applying heat insulation. Ames Research Center is investigating the feasibility of blanket-type materials while Lockheed won a study contract to research other approaches.

Six hundred tiles contain sensors which will report temperatures, strain loading and other measurements during flight. Overall, the insulation materials applied to "Columbia" will add up to 9½ tons.

Five years ago NASA expected to "turn around" an orbiter: that is, purge its systems, replace damaged tiles, and otherwise ready it for another mission in 10 working days. That has increased to 14 days. Donald Phillips, KSC representative working with Overmyer, suggested that figure is "only a goal – there will be many changes after Flight No. 1."

The launch base, to which Shuttles will return from space missions, planned to screen tiles by an infrared device which would ferret out those damaged by flight conditions. Phillips revealed that concept has been dropped; instead, every tile must be individually inspected which raises further question about a 14-day turnaround.

Rockwell sent tile installers and technicians to Florida to complete their work on "Columbia" in March. After several months of below par performance, the contractor was authorized to increase his force. People available in the immediate vicinity were hired and trained; whether sufficient foresight was exercised is a new question.

Overmyer praised their efforts but acknowledged that some installers are college students who wished to return to classes in September. Meanwhile many of the California itinerants who brought families with them wished to return home so children could continue schooling.

These losses must be made up by new hires and more training, but Overmyer optimistically predicted the manufacturing will be completed by Thankgiving.

Ex-Navy Captain Lee Scherer, director of Kennedy Space Center since 1974, will be transferred to NASA headquarters in Washington to make way for Richard Smith, 19-year veteran and graduate of the von Braun Saturn programme in Alabama, who took over on 2 September. The agency denied that the change had anything to do with the troubled Shuttle programme.

SPECIAL MEETING HONOURS CAPTAIN FREITAG

At a Special Meeting held in the Auditorium of the American Embassy in London on 16 July, the Society's Bronze Medal for distinguished services to Astronautics was presented to Captain Robert F. Freitag, Deputy Director, Advanced Programs, Office of Space Transportation Systems, National Aeronautics and Space Administration.

In making the presentation, Mr. G. V. E. Thompson, President, said it was the Society's custom to acknowledge people who had made significant contributions to the science and technology of space flight. Captain Freitag, a Fellow of the Society of long-standing, had in fact made considerable contributions in several departments which ranged from the management of important U.S. rocket programmes to major space projects within NASA.

Captain Freitag was currently Deputy Director of the Advanced Programs Office responsible for planning and developing future manned space programmes for NASA. This included advanced transportation, space stations and space platforms, advanced space operations and new missions beyond the present Space Transportation Program.

This responsibility includes the development of long-range plans, conducting advanced development of critical sub-systems, coordinating with outside agencies and international groups and management planning associated with new programmes. Prior assignments with NASA included Special Assistant to the Associate Administrator

BIS HONOURS MEETING. President G. V. E. Thompson addresses a distinguished gathering at the American Embassy, London, on 16 July 1979 when the BIS Bronze Medal was presented to Captain Robert Freitag "for outstanding contributions to Astronautics."

Left to right, Professor G. V. Groves (Past President), L. J. Carter (Executive Secretary), U.S. Ambassador Brewster and Captain R. Freitag.
Photos: International Communication Agency

involved with the establishment of the Post-Apollo programme of international cooperation and policy planning for present and future manned space flight programmes, Director of Field Center Development for the Office of Manned Space Flight from November 1963 to January 1971 and Director of Launch Vehicles and Propulsion, OMSF from March to November 1963.

Captain Freitag was born in Jackson, Michigan, on 20 January 1920. He graduated from the University of Michigan (BSE Aeronautical Engineering) in 1941, and performed graduate work in Aeronautical Engineering at Massachusetts Institute of Technology during 1941-42. In 1941, he was commissioned an Ensign in the Naval Reserve.

Captain Freitag has been involved in the guided missile and rocket field since 1945. These assignments included obtaining rocket and missile information from Germany; aerodynamic development of Navy guided missiles; establishment of supersonic wind tunnels; guided missile intelligence assignments; and direction and establishment of the basic instrumentation system for Air Force Eastern Test Range, Cape Canaveral, Florida.

In 1951, Captain Freitag received a special commendation from the Commander-in-Chief, Pacific Fleet for planning and operations associated with the first Navy guided missile employed during the Korean War. In 1953-55, he was assigned to the Navy Bureau of Aeronautics, Washington, D. C., where he was in charge of the REGULUS missile programme during which period the REGULUS I became operational. In 1955 he was Head, Ballistic Missile Branch during which period the basic concepts of the Polaris and Subroc missiles were evolved. From 1955-57, he was Project Officer in the Office of the Chief of Naval Operations on the Jupiter and Polaris intermediate range ballistic missiles and the Vanguard Earth satellite. During this period, he served additional duty on the Secretariat of Joint Army-Navy Ballistic Missile Committee and on the Staff, Secretary of Defense Special Assistant for Guided Missiles.

From 1957-59, he was assigned successively as the Range Planning Officer on the Staff of the Director, Range Support; Pacific Missile Range Planning Officer; and finally as Special Assistant to the Commander, Pacific Missile Range, Point Mugu and Point Arguello, California.

From 1959-63, Captain Freitag directed space and astronautics systems development, supporting research, operational planning , and programme management at the Bureau of Naval Weapons.

Additionally, Captain Freitag has served on numerous missile and engineering groups including National Advisory Committee for Aeronautics Subcommittee on Propellers (1944-46); NACA Special Committee on Space Technology (1958-59) and NASA Research Advisory Committee on Missile and Spacecraft Aerodynamics (1960-63). From 1956 through 1958, he was a member of the Secretary of Defense Special Committee on Adequacy of Range Facilities For this work Captain Freitag received an outstanding commendation from the Secretary of Defense. From 1960 to 1964, he was a member of the Launch Vehicle Panel of the NASA/DOD Aeronautics and Astronautics Coordinating Board.

In 1957, he was designated "Distinguished Alumnus" by the University of Michigan. In 1959, he was awarded the Legion of Merit for "outstanding services to the Government of the United States from 1949 to 1959, in connection with Naval and National Guided Missile Programs... and for developing and selling the Fleet Ballistic Missile concept to the Navy and the Secretary of Defense..." More recently, Captain Freitag was awarded the Secretary of the Navy Commendation Medal for outstanding performance and achievement as the first Director of Astronautics for the Navy. In 1967, Captain Freitag was awarded the University of Michigan Sesquicentennial Award and Medal. In 1969, Captain Freitag received the NASA Exceptional Service Medal for his contributions to manned space flight and the Apollo lunar landing.

Next month we shall be publishing the address by Captain Freitag, which reviews the contemporary environment for space development in the United States. Ed.

BOOK REVIEW

Orbital Motion
By A E Roy, Adam Hilger Ltd., pp.489, 1978, £15.00

Of necessity this is an extremely mathematical textbook and is intended for the theoretically minded reader with a knowledge of calculus and elementary vector analysis. The comprehensive text requires very little in the way of background information on astronomy or space science, and the types of motion possible are contained in a brief survey of the structure of the universe. Also the important topics of coordinates and time, reduction of observational data (refraction, precession, etc.) are summarized with an excellent collection of definitions and formulae.

The simplest topic is the two body problem and the elliptic, parabolic, and hyperbolic orbits are discussed in some detail. This includes the formulae for calculating an ephemeris of a body from the orbital elements.

Three chapters cover the many body problems and general and special perturbations. Included is the Lagrangian solution to the three body problem which is necessary for an understanding of the Trojans' orbits. Of course most of the solutions here have to be found by numerical methods and the principles of numerical integration are sufficiently explained in the text.

Large scale numerical integration is also used in the topic of the stability and evolution of the solar system. The moon is not forgotten either and is dealt with from the most simple theory of rotation up to the complex problem of secular acceleration.

Probably of most interest to the majority of BIS members are the chapters on space science. From a review of forces acting on artificial Earth satellites we are led into the dynamics of rockets and space probes. Orbit transfer and determination lead naturally into a topic of major importance (an importance enhanced by the success of Voyager I), namely interplanetary navigation. Binary stars and stellar systems complete this very comprehensive book.

The whole volume is well presented and contains over 200 useful references. Also many problems with solutions are included which range from the very easy to the reasonably difficult.

T G COOK

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Lecture
Title: **THE INTERNATIONAL SOLAR POLAR MISSION**
by D. Eaton (ISPM Project Manager)
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **21 November 1979**, 7.00-9.00 p.m.
Admission tickets are not required. Members may introduce guests.

Visit
Arrangements are being made for a small party of members to make a return visit to PERME at Westcott, near Aylesbury, Bucks, on **4 December 1979** *(all day)*.

The excursion will be by train to and from Aylesbury (departure Marylebone Station).

Registration is necessary. Members interested in participating *must* apply to the Executive Secretary, enclosing a **reply-paid envelope** before 20 November 1979.

Study Course
Title: **THE EXTRAGALACTIC DISTANCE SCALE**
by Dr. D. A. Hanes
To be held in the Golovine Conference Room, Society H.Q., 27/29 South Lambeth Road, London, SW8 1SZ on **5 December 1979**, 6.30-9.00 p.m.
Registration is necessary. For further details apply to the Executive Secretary.

Film Show
Theme: **SPACE PROBES**
To be held in the Botany Lecture Theatre, University College, Gower Street, London, W.C.1. on **12 December 1979**, 7.00-9.00 p.m.

The programme will be as follows:-

Earth-Space – Our Environment	Mercury – Exploration of a Planet
Mars and Beyond	The Planet Mars
HEAO – The New Universe	Life

Admission tickets are not required. Members may introduce guests.

Study Course
Title: **EVOLUTION OF STELLAR SYSTEMS**
by Dr. J. Jones
To be held in the Golovine Conference Room, Society H.Q., 27/29 South Lambeth Road, London, SW8 1SZ on **2 January 1980**, 6.30-9.00 p.m.
Registration is necessary. For further details apply to the Executive Secretary.

Technical Forum
This is the first of a new type of meeting in the Society's new building to enable small technical groups to discuss subjects of particular interest at a suitably high level.

To be held in the Golovine Conference Room, Society H.Q., 27/29 South Lambeth Road, London, SW8 1SZ on **4 January 1980**, 6.30-9.00 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**
The Speakers will include the following:–

Phillip S. Clark	– The G Vehicle – Phoenix or Dinosaur?
Ralph F. Gibbons	– A Reappraisal of the Soyuz 1 to 9 Flights
David Hawkins	– Visual Observation of Soviet Spacecraft
Nicholas I. Porter	– The Soyuz Programme
Michael Richardson	– The Salyut 6 Mission

Members with a special interest in the Soviet Space Programme are invited to attend.

No fee is payable but registration *is* necessary. Forms are available from the Executive Secretary on request enclosing a reply-paid envelope.

Study Course
Title: **X-RAYS IN THE UNIVERSE**
by Dr. A. C. Fabian
To be held in the Golovine Conference Room, Society H.Q., 27/29 South Lambeth Road, London, SW8 1SZ on **23 January 1980**, 6.30-9.00 p.m.
Registration is necessary. For further details apply to the Executive Secretary.

Visit
A tour of the Astronomy and Space Galleries of the Science Museum, Exhibition Road, London, S.W.7, accompanied by Dr. John Becklake will take place on **12 February 1980**, commencing at 6.30 p.m.

Admission (restricted to members only) will be by ticket available from the Executive Secretary on request enclosing a **reply-paid enevlope.**

Study Course
Title: **FUTURE OBSERVATION IN COSMOLOGY**
by Dr. C. D. Mackay
To be held in the Golovine Conference Room, Society H.Q., 27/29 South Lambeth Road, London, SW8 1SZ on **20 February 1980** 6.30-9.00 p.m.
Registration is necessary. For further details apply to the Executive Secretary.

17th European Space Symposium
Theme: **ASTRONAUTICS IN THE NEXT 50 YEARS**
A 3-day meeting to be held at the Royal Commonwealth Society, London, W.C.2, from **4-6 June 1980**, sponsored by the BIS, AA

Offers of Papers are invited. Please contact the Executive Secretary for further information.

Registration is necessary. Copies of the programme will be available in due course. Arrangements will be made for accommdation to be provided at the Swan's Nest Hotel: booking forms will be provided on request.

31st IAF Congress
The 31st Congress of the International Astronautical Federation will be held in the Takanawa Prince Hotel, Takanawa, Minato-ku, Tokyo, Japan from **21-28 September 1980.**

Members of the Society intending to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liaison Committee at Society H.Q. as soon as practicable. Further information on the Congress will be published as it comes to hand.

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